Public Disclosure Authorized

Public Disclosure Authorized

ECONOMIC ANALYSIS OF AGRICULTURAL PROJECTS

Second Edition, Completely Revised and Expanded

J. PRICE GITTINGER

HD 1417 .G58 1982 c.3
GITTINGER, J. PRICE
ECONOMIC ANALYSIS OF
- AGRICULTURAL PROJECTS.

UNN76

JOINT BANK-FUND LIBRARY
HD1417 .G58 1982 c.3
Economic analysis of agricultural projects /
JLC029705

Public Disclosure Authorized

EDI SERIES IN ECONOMIC DEVELOPMENT

Economic Analysis *of* Agricultural Projects

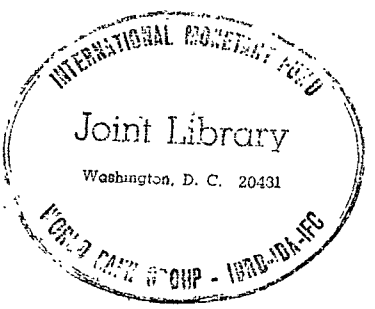
EDI SERIES IN ECONOMIC DEVELOPMENT

HD
1417
G58
1982
c 3

Economic Analysis *of* Agricultural Projects

Second Edition,
Completely Revised and Expanded

J. Price Gittinger



PUBLISHED FOR
THE ECONOMIC DEVELOPMENT INSTITUTE
OF THE WORLD BANK
The Johns Hopkins University Press
BALTIMORE AND LONDON
1982

SECOND EDITION, COMPLETELY REVISED AND EXPANDED,
COPYRIGHT © 1982 BY THE INTERNATIONAL BANK
FOR RECONSTRUCTION AND DEVELOPMENT / THE WORLD BANK
1818 H STREET, N.W., WASHINGTON, D.C. 20433, U.S.A.
ALL RIGHTS RESERVED
MANUFACTURED IN THE UNITED STATES OF AMERICA

The Johns Hopkins University Press
Baltimore, Maryland 21218, U.S.A.

The views and interpretations in this book are the author's and should not be attributed to the World Bank, to its affiliated organizations, or to any individual acting in their behalf.

EDITOR James E. McEuen
PRODUCTION Christine Houle
FIGURES Raphael Blow
INDEX Ralph Ward and James Silvan
BOOK DESIGN Brian J. Svikhart
COVER DESIGN Joyce C. Eisen

Photo credits: World Bank photographs (facing pages) by Hilda Bijur, 437; William Graham, 431; Per Gunvall, 188; Yosef Hadar, 242; Edwin Huffman, papercover, 298; Jaime Martín-Escobal, 42, 411; Peter C. Muncie, 64; James Pickerell, 286; Tomas Sennett, frontispiece, 362, 445, 457; and Ray Witlin, 2, 84, 214.

Frontispiece: Milking tethered sheep in Syria.

• Karya ini tersedia pula dalam Bahasa Indonesia dengan judul *Analisa Ekonomi Proyek-Proyek Pertanian* diterbitkan oleh Penerbit Universitas Indonesia (Jln. Salemba Raya 4, Jakarta).

• Une version en français de cet ouvrage a été publiée sous le titre *Analyse économique des projets agricoles*, Editions Economica (49, rue Héricart, 75015 Paris, France; distributeur au Canada: Le Diffuseur, C.P. 85, Boucherville, Québec J4B 5E6).

• Esta obra también ha sido publicada en español bajo el título *Análisis económico de proyectos agrícolas*, por la Editorial Tecnos (distribución en España: Grupo Editorial, S.A., Don Ramón de la Cruz 67, Madrid 1; distribución en otros países: GSR Internacional, Villafranca 22, Madrid 28, España).

Library of Congress Cataloging in Publication Data:
Gittinger, J. Price (James Price), 1928–
Economic analysis of agricultural projects.
(EDI series in economic development)
Bibliography: p. 445
Includes index.
1. Underdeveloped areas—Agriculture—Cost effectiveness. 2. Agriculture—Economic aspects.
I. Title. II. Series.
HD1417.G58 1982 338.1'3 82-15262
ISBN 0-8018-2912-7 AACR2
ISBN 0-8018-2913-5 (pbk.)

Foreword

TO INCREASE THE GROWTH AND EFFICIENCY of the agricultural and rural sectors of the developing countries is of prime concern to the international community. More rapid progress is crucial not only to improve the quality of life of the 60 percent of the world's population earning its living from rural labor, but also to ensure adequate food supplies for all nations in the face of rapid worldwide population growth and rising incomes that lead people to want more and better-quality food. Unless domestic food production in developing countries steadily increases, these requirements will place unbearable strains on the world's food production and distribution system—threatening widespread malnutrition in the poorest countries and adding to inflationary pressures in the industrial nations.

In the next few years, agriculture and rural development will be a priority in the lending programs of The World Bank and International Development Association (IDA). The World Bank will maintain its support of member governments with technical expertise and a continuing flow of resources. It will help governments to expand irrigation systems, provide more effective extension services, increase food storage capacity, disseminate agronomic technology, and improve the marketing and distribution of agricultural goods.

This effort will require large quantities of scarce resources—both people and money—from our member nations and from the Bank itself. We must use these resources efficiently.

Since its founding the Bank has encouraged, indeed insisted upon, the responsible preparation of the development projects for which it lends. This book is one more implement by which the agricultural work of the Bank is carried out.

The Bank shares its experience and skill with member governments and their technical and administrative staffs so that wise and careful investment decisions will yield higher national incomes and a better quality of life for the people of the developing world. In no sector is this sharing of information more important than in agriculture and rural development, where sound investment has such effects on the lives of millions.

The Economic Development Institute (EDI) has played an important role in disseminating the Bank's experience. Since its founding in 1954, more than 10,000 senior officials from member governments have attended EDI courses both at headquarters in Washington, D.C., and overseas. EDI has helped dozens of institutions throughout the world to provide courses in economic management and project analysis in their own curricula.

Economic Analysis of Agricultural Projects derives from the Bank's concern to hasten agricultural and rural development and from the course activities of EDI. The book presents a sound, careful methodology for project analysis based on the efforts of agricultural specialists in the Bank and throughout the world. Care has been taken to make the technical topics discussed understandable to those without advanced training in economics. The book was written to be used either in individual study or in the classroom.

We are pleased that the first edition has enjoyed such wide acceptance. Since it was published in 1972, it has become a standard text for those planning agricultural projects and teaching project analysis. In offering this revised edition, with expanded coverage and the addition of more recent experience, we hope to make its contribution even more effective.

A. W. CLAUSEN
President
The World Bank

Washington, D.C.
June 1982

Contents

Foreword *by A. W. Clausen* *v*

Preface *xiii*

Using This Book *xvii*

PART ONE The Project Concept

1. *Projects, The Cutting Edge of Development* *3*
   - What Is a Project? *4*
   - Plans and Projects *6*
   - Advantages of the Project Format *7*
   - Limitations of the Project Format *9*
   - Aspects of Project Preparation and Analysis *12*
     - *Technical aspects* *12*
     - *Institutional-organizational-managerial aspects* *13*
     - *Social aspects* *15*
     - *Commercial aspects* *16*
     - *Financial aspects* *16*
     - *Economic aspects* *18*
   - The Project Cycle *21*
     - *Identification* *21*
     - *Preparation and analysis* *22*
     - *Appraisal* *24*
     - *Implementation* *24*
     - *Evaluation* *25*
   - Accuracy of Agricultural Project Analyses *26*
     - *Economic effects* *27*

Effect on incomes of rural poor 28
Implementation experience 28
Why Agricultural Project Analyses Prove Wrong 29
Problems of project design and implementation 29
Problems of poor project analysis 35
Steps in Project Analysis 37

2. *Identifying Project Costs and Benefits* 43
Objectives, Costs, and Benefits 43
"With" and "Without" Comparisons 47
Direct Transfer Payments 50
Costs of Agricultural Projects 52
Physical goods 52
Labor 53
Land 53
Contingency allowances 53
Taxes 54
Debt service 54
Sunk costs 55
Tangible Benefits of Agricultural Projects 56
Increased production 56
Quality improvement 57
Change in time of sale 57
Change in location of sale 57
Changes in product form (grading and processing) 58
Cost reduction through mechanization 58
Reduced transport costs 58
Losses avoided 58
Other kinds of tangible benefits 59
Secondary Costs and Benefits 59
Intangible Costs and Benefits 61

PART TWO Financial Aspects of Project Analysis

3. *Pricing Project Costs and Benefits* 65
Prices Reflect Value 65
Finding Market Prices 69
Point of first sale and farm-gate price 70
Pricing intermediate goods 71
Other problems in finding market prices 72
Project boundary price 74
Predicting Future Prices 74
Changes in relative prices 75
Inflation 76
Prices for Internationally Traded Commodities 77
Financial Export and Import Parity Prices 78

4. *Farm Investment Analysis* 85
Objectives of Financial Analysis 86
Assessment of financial impact 86
Judgment of efficient resource use 86
Assessment of incentives 86
Provision of a sound financing plan 87
Coordination of financial contributions 87
Assessment of financial management competence 87

Preparing the Farm Investment Analysis 89
Elements of Farm Investment Analysis 95
Accounting convention for farm investment analysis 95
Farm resource use 99
Farm production 111
Farm inputs 119
Farm budget 127
Net Benefit Increase *140*
Unit Activity Budgets *141*
Computing Debt Service *147*
Simple interest 147
Repayment of equal amounts of principal 150
Equal installments 153
Equal installments with interest capitalized 157
Declining real burden of debt service 158
Appendix. Herd Projections *163*
Terminology and definitions 164
Computational conventions 164
Technical coefficients 165
Animal units 174
Determining the stable herd 175
Tracing the herd growth 179
Machine computation 183
Feed budget 183

5. *Financial Analysis of Processing Industries* *189*
Balance Sheet *192*
Income Statement *195*
Sources-and-Uses-of-Funds Statement *198*
Financial Ratios *202*
Efficiency ratios 203
Income ratios 206
Creditworthiness ratios 207
Financial Rate of Return *209*

6. *Analyzing Project Effects on Government Receipts and Expenditures* *215*
Government Cash Flow *217*
Foreign Exchange Flow *220*
Cost Recovery *222*
Objectives of cost recovery 223
Setting the level of water charges and benefit taxes 225
Measuring cost and rent recovery 226
Joint Cost Allocation *233*
General principles of cost allocation 233
Separable costs–remaining benefits method 234

PART THREE Economic Aspects of Project Analysis

7. *Determining Economic Values* *243*
Determining the Premium on Foreign Exchange *247*
Adjusting Financial Prices to Economic Values *250*
Step 1. Adjustment for direct transfer payments 251
Step 2. Adjustment for price distortions in traded items 251
Step 3. Adjustment for price distortions in nontraded items 253

Indirectly traded items 265
Economic export and import parity values 269
Trade Policy Signals from Project Analysis 271
Valuing Intangible Costs and Benefits 279
Decision Tree for Determining Economic Values 284

8. *Aggregating Project Accounts* 287
Aggregating Farm Budgets 287
Other Aggregation Issues 289
Appendix. A Diagrammatic Project Model 291
Measures of national income 292
Value added 293
Project model 293

PART FOUR Measures of Project Worth

9. *Comparing Project Costs and Benefits* 299
Undiscounted Measures of Project Worth 300
Ranking by inspection 300
Payback period 302
Proceeds per unit of outlay 302
Average annual proceeds per unit of outlay 303
Average income on book value of the investment 303
The Time Value of Money 304
Interest 305
Compounding 305
Discounting (present worth) 308
Present worth of a stream of future income 309
Discounted Measures of Project Worth 313
Choosing the discount rate 313
Discounting convention for project analysis 315
Derivation of Incremental Net Benefit (Incremental Cash Flow) 315
Net Present Worth 319
Internal Rate of Return 329
Computing the internal rate of return 332
Reinvestment of returns 339
More than one possible internal rate of return 339
Point in time for internal rate of return calculations 341
Benefit-Cost Ratio 343
Net Benefit-Investment Ratio 346
Selecting among Project Alternatives 350
What Happened to Depreciation? 351
Length of the Project Period 355
How Far to Carry Out Computations of Discounted Measures 356
Comparisons among Discounted Measures 358
Appendix. Mathematical Formulations of Discounted Measures of Project Worth 361

10. *Applying Discounted Measures of Project Worth* 363
Sensitivity Analysis (Treatment of Uncertainty) 363
Price 364
Delay in implementation 364
Cost overrun 364
Yield 365
Technique of sensitivity analysis 365
Switching Value 371

Choosing among Mutually Exclusive Alternatives *373*
Entirely different projects 377
Different scales of a project 379
Different timing of a project 381
Choice between technologies (crossover discount rate) 383
Additional purposes in multipurpose projects 388
Applying Contingency Allowances *393*
Replacement costs 395
Residual value 397
Domestic resource cost 398
Calculating Measures of Project Worth Using Current Prices *400*
Calculator Applications in Project Analysis *401*

Appendixes
A. *Guidelines for Project Preparation Reports* *411*
1. Summary and Conclusions *412*
2. Introduction *412*
3. Background *413*
3.1 Current economic situation 413
3.2 The agricultural sector 413
3.3 Development and social objectives 413
3.4 Income distribution and poverty 413
3.5 Institutions 414
4. Project Rationale *414*
5. The Project Area *414*
5.1 Physical features 414
5.2 Economic base 415
5.3 Social aspects 416
5.4 Infrastructure 417
5.5 Institutions 417
6. The Project *417*
6.1 Project description 418
6.2 Detailed features 418
6.3 Project phasing and disbursement period 419
6.4 Cost estimates 420
6.5 Financing 421
6.6 Procurement 422
6.7 Environmental impact 422
7. Organization and Management *422*
7.1 Credit administration 423
7.2 Marketing structure 423
7.3 Supply of inputs 424
7.4 Land reform 424
7.5 Research 424
7.6 Extension 424
7.7 Cooperatives 424
7.8 Farmer organization and participation 424
8. Production, Markets, and Financial Results *425*
8.1 Production 425
8.2 Availability of markets 425
8.3 Farm income 426
8.4 Processing industries and marketing agencies 426
8.5 Government agencies of project authorities 426
8.6 Cost recovery 426

9. Benefits and Justification *427*
9.1 Social benefit *427*
9.2 Economic benefit *428*
10. Outstanding Issues *428*
11. Annexes *428*

B. *Three-decimal Discounting Tables* *431*
Compounding Factor for 1 *432*
Compounding Factor for 1 per Annum *432*
Sinking Fund Factor *432*
Discount Factor *433*
Present Worth of an Annuity Factor *433*
Capital Recovery Factor *433*

C. *Sources of Institutional Assistance for Project Preparation* *437*
Bilateral Assistance *437*
Multilateral Assistance *437*
European Community *438*
United Nations Development Programme *438*
Food and Agriculture Organization–Development Bank Cooperative Programs *439*
World Bank *440*
Consultants *441*

Bibliography 445

Glossary-Index 457

Preface

THIS BOOK was written to provide those responsible for agricultural investments in developing countries with sound analytical tools they can apply to estimate the income-generating potential of proposed projects.

Scope and Methodology

The book has not been written only for a narrow grouping of agricultural economists. Rather, it is intended for all who must share in shaping agricultural projects if these undertakings are to be high-yielding investments: agronomists, livestock specialists, irrigation engineers, and many others. All these people are meant when the term "analyst" is used. To the existing resources of these diverse professionals, the book adds a tool for multidisciplinary use so that many with many skills can work together in applying their knowledge to analyze proposed projects.

The formal economic theory underlying the analytical system outlined here is not complicated; it certainly is not so technical as to cause problems for noneconomists. For those not already familiar with it, I have discussed the necessary economic theory in the course of the presentation and have defined technical terms both in the text and in the glossary-index at the end of the book. The mathematical techniques used are also simple; they are limited to addition, subtraction, division, multi-

plication, and the simplest algebra. The computations needed for project analysis, however, are too tedious to be done by hand. A simple electronic calculator is a virtual necessity (see chapter 10 under "Calculator Applications in Project Analysis"), but there is no need for advanced calculators or computers.

The analytical system outlined in this book is a consistent statement of the general methodology currently employed by the World Bank for all but a few of its project analyses (Gittinger, Garg, and Thieme 1982). (The details of World Bank analyses vary somewhat according to the sector and the views of individual analysts.) With minor variations, the system is also used by most international agencies concerned with capital transfer, including the African Development Bank, the Asian Development Bank, and the Inter-American Development Bank. The economic analysis in this system is based on "efficiency prices"—prices that show effects on national income broadly defined. The system enables us to judge which among project alternatives is most likely to contribute the largest amount to national income. The system underlies millions of dollars of investment decisions made every year. Thick volumes of economic analysis backing up proposed investments usually involve nothing more complicated than what is discussed in the following pages—although large investments may require much elaboration and may involve intermediate steps to accommodate all the "ins" and "outs" of a complex agricultural project.

In recent years several analytical systems have been proposed that extend the methodology outlined here to take into account not only the contribution a project makes to national income but also the effect of a project on income distribution and saving. Most notable are those of Little and Mirrlees (1974), the United Nations Industrial Development Organization (UNIDO) (1972*a*), and Squire and van der Tak (1975). These analytical systems, which remain the subject of much professional discussion, are far more complex than the one I have presented. The system outlined here, however, is compatible with these more complex systems; in fact, Squire and van der Tak recommend the same methodology for project identification and valuation. The difference is that, once Squire and van der Tak have determined economic values on the basis of efficiency prices, they then proceed to weight those values to account for income distribution and saving. In the analytical system given here, we will stop with the efficiency price analysis. We will then suggest making a subjective decision to choose among the high-yielding alternatives the one that has the most favorable effects on income distribution, saving, and other national objectives. The system outlined here is not immediately adaptable to the Little and Mirrlees or the UNIDO systems, but there are no major conceptual differences up to the point we carry the analysis. Both Little and Mirrlees and UNIDO recommend further refinements to allow for the effects on income distribution and saving that are not incorporated in the formal analytical scheme recommended here.

The Revised Edition

Compared with the first edition, published in 1972, this second, revised edition has an expanded discussion of the project approach that incorporates more recent experience and provides more detailed and rigorous treatment of identifying, pricing, and valuing costs and benefits. The basic analytical system, however, is unchanged. Much additional material has been added on farm budgets and other aspects of financial analysis, and a bit more on the methodology of comparing costs and benefits.

In the Economic Development Institute (EDI), the first edition has been extensively used for teaching project analysis. The sequence of topics taken up in EDI courses on agricultural and rural development, rural credit, livestock, and irrigation projects generally follows the order found here. Thus, the overall concept of a project is presented first, followed by farm budgets and financial analysis, and then by economic analysis. (For a more detailed description of the process of project analysis, and of the organization of the chapters in this book, see the last section of chapter 1, "Steps in Project Analysis.") In practice, however, the methodology of comparing costs and benefits discussed in chapters 9 and 10 is usually taught in parallel with the topics on financial and economic analysis. This both permits a change of pace in the teaching and gives course participants more time to practice using methodological tools before proceeding to case studies in which they are asked to apply their knowledge of financial and economic analysis and their methodological skills. EDI has prepared a number of case studies and other training materials to teach agricultural and rural development project analysis, and these are available to others teaching these subjects. (See the last page of this book for information about how to obtain these materials.)

Acknowledgments

I could never have written a book such as this without extensive help from many, many people. The book grows out of lectures and training materials prepared for EDI courses, and its style reflects its origin. I have benefited enormously from, and this revised edition has been informed by, participants in these courses both at EDI headquarters and in developing countries. Readers will note I have made liberal use of training materials prepared by my colleagues.

It is impossible to acknowledge all the individuals who have helped me, but special appreciation should be expressed to Hans A. Adler, George B. Baldwin, Maxwell L. Brown, Colin F. M. Bruce, Orlando T.

Espadas, F. Leslie C. H. Helmers, P. D. Henderson, William I. Jones, Klaus Meyn, Frank H. Lamson-Scribner, David H. Penny, Walter Schaefer-Kehnert, Arnold von Ruemker, Jack L. Upper, and William A. Ward, all presently or formerly with the EDI; to numerous present and former staff working with agricultural projects in the World Bank, especially Graham Donaldson, Lionel J. C. Evans, John D. Von Pischke, Gordon Temple, Willi A. Wapenhans, and A. Robert Whyte; and to Frederick J. Hitzhusen, Ohio State University, and John D. MacArthur, University of Bradford.

J. PRICE GITTINGER

Using This Book

THE ORGANIZATION, conventions and notation, and special features of this book are briefly explained here at the outset for the reader's convenience.

Organization of Chapters

Chapters are presented in an order that in general follows the process of preparing an agricultural project analysis. The sequence of this process is described in the last section of chapter 1, "Steps in Project Analysis." Because the analytical process is iterative, chapters frequently contain cross-references to appropriate sections and subsections in other chapters.

Computations

Project analyses rest on many assumptions that by their very nature are only approximate. The final results of computations, therefore, should be rounded with this limitation in mind and presented appropriately with only significant digits included—say, in millions or thousands of currency units, thousands or hundreds of tons or hectares, or the like. To make methodological points more apparent, however, many illustrative computations in this book have been carried out much

further than called for by such a rule. Hence, they should not be taken as a model for presentation. (See the section in chapter 9 entitled "How Far to Carry Out Computations of Discounted Measures" for a discussion of this topic.)

Decimals and commas in numbers

Throughout this book, a decimal is indicated by a point set level with the bottom of the line of type (.). In numbers of 1,000 or greater (except those designating the year), a comma (,) distinguishes groupings of thousands. Thus, 1 million would be written 1,000,000.0. Whenever a decimal fraction appears that is less than 1, a zero appears before the decimal point to avoid misreading the fraction; thus, one-fourth appears in decimal form as 0.25.

Rounding convention

For all computations in this book, the following rules have been used for rounding:

1. When a value of less than 5 is to be dropped, the digit to the left is unchanged.
2. When a value of more than 5 is to be dropped, the digit to the left is increased by 1.
3. When a value of *exactly* 5 is to be dropped, the digit to the left, if *even*, is left unchanged; if *odd*, it is raised by 1. Under this rule, all numbers that have been rounded by dropping an *exact* value of 5 are reported as even numbers.

Thus, in the first illustrative tabulation in the "Compounding" subsection of chapter 9, the following rounding will be found:

1,050 × 1.05 = 1,102.50 *rounded to* 1,102 (Rule 3)
1,102 × 1.05 = 1,157.10 *rounded to* 1,157 (Rule 1)
1,157 × 1.05 = 1,214.85 *rounded to* 1,215 (Rule 2).

Calculations

Throughout the text, illustrative calculations made in project analysis are given (within parentheses or brackets) after the explanation of how they are derived. Most of these calculations are done by simple arithmetic. (For the sake of completeness, there are many calculations presented in this manner that are very simple; I hope the reader will be patient with such obvious examples.) More elaborate formulas are displayed on the page.

Units of Measurement and Currency

Metric units are used for all measurements unless otherwise specified—thus, "tons" refers to metric tons, not "long" or "short" tons.

Special units—for example, "animal units" or "work days"—are defined in the text and in the glossary-index (see "Supporting Materials," below).

To emphasize the worldwide scope of agricultural development efforts, examples of project accounts give money amounts in the currency of the country in which the project is located. The standard symbols for these currencies are identified in the text and tables; when appropriate, generic "currency units" are also used.

Notation

An explanation of the conventions used for notation in this book may help in reading the tables, mathematical formulations, and the six-decimal discount factors.

Tables

In the tables in this book a zero indicates "none" or "no amount," and a dash (—) indicates "not applicable." In chapters 4, 5, and 6, and in tables 9-7 and 9-8 where financial accounts are discussed, the accounting convention of indicating negative numbers by parentheses has been adopted. In all other tables, negative numbers are indicated by a minus sign (−).

The tables in this book are of several general kinds: tables that lay out methods of calculation (for example, tables 3-3 and 7-2); "pattern account" tables that lay out a recommended format for project accounts for either financial analysis (the tables in chapter 4) or economic analysis (the tables in chapter 7); and the usual sort of table that simply presents project data.

In some of the pattern account tables additional information for understanding (for example, the financial or economic rate of return) is given after the main rows of entries. The reader is reminded that, to arrive at the total values in the tables of chapters 9 and 10 that include entries for multiyear spans, annual amounts must be included for the number of years involved.

In tables that illustrate financial accounts, the reader should note that in some cases intervening years have been omitted (see, for example, table 5-1).

To aid computation, portions of *Compounding and Discounting Tables for Project Evaluation* (Gittinger 1973) have been reproduced in the seven compounding and discounting tables that appear in this book.

Mathematics

As noted above, standard arithmetical notation has been used throughout the book. When division is indicated in a line of figures, a division sign (÷) is used rather than a slash (/).

In the section in chapter 10 entitled "Calculator Applications in Project Analysis" the operations that are indicated on the keys of the simple electronic calculator used are shown in the text in **boldface** type.

Six-decimal discount factors

When six-decimal discount factors are used in the text or in tables, a notation of inserting a space between the third and fourth decimal places has been followed to make the factors easier to read.

Technical Terms

Specialized financial, accounting, economic, and project terms (and the few acronyms and abbreviations used in the book) have been compiled and defined in the glossary-index (see "Supporting Materials," below). The most important of these, of course, are also defined in the text where they apply.

As a guide to understanding the format of project accounts, the principal headings of the pattern account tables—categories that are likely to appear in most agricultural project analyses—have been listed in *italic* type in the text of chapters 4, 5, 6, and 8.

Supporting Materials

The reader may find supporting materials that are included in this book, or available from the sources indicated, helpful for further study of project analysis.

Appendixes

Chapter appendixes supplement the discussion of topics in chapters 4, 8, and 9. Appendixes to the book provide general guidelines for preparing an agricultural project analysis report (appendix A); give summary discounting tables for common discount rates and the formulas for computing discount factors directly using an electronic calculator (appendix B); and discuss the bilateral and multilateral sources of specialized assistance for the preparation of complex agricultural projects (appendix C). The assistance discussed in appendix C is negotiated and undertaken at the institutional level by the agencies and governments involved.

Bibliographic sources

Primary sources have been identified in the text by the author's surname and the publication date of the material cited. These sources, and additional references, are listed and annotated in the bibliography.

Sources of some individual tables and figures are not listed in the bibliography but are cited in full in the appropriate table or figure legend. Some of these source materials have restricted circulation and are unavailable to the general public.

I could not have written this book without access to the experience of the Economic Development Institute (EDI) and its parent institution, the World Bank. The record of this experience is predominantly in the public domain. Information about how to obtain publications of the EDI and of the World Bank will be found on the last page of this book.

Glossary-Index

As an aid to the reader, the index has been enhanced by incorporating glossary entries that define the principal technical terms used in this book. Because interpretation of some of these terms varies among the specialists involved in preparing agricultural project analyses (these professionals are an inquisitive lot—they have to be—and the field is a dynamic and changing one), the definitions given cannot be "definitive"—they reflect the use of these terms in this book.

Project examples

Data from actual agricultural project investments assisted by the World Bank or other international development agencies or financed by governments have been used to illustrate the analytical methodology presented here. The adaptation and interpretation of these data are my own. The use of project information in this book is purely illustrative; it does not represent a judgment by the funding agency or borrowing government about any particular project.

PART ONE

The Project Concept

1

Projects, The Cutting Edge of Development

PROJECTS ARE THE CUTTING EDGE OF DEVELOPMENT. Perhaps the most difficult single problem confronting agricultural administrators in developing countries is implementing development programs. Much of this can be traced to poor project preparation.

Project preparation is clearly not the only aspect of agricultural development or planning. Identifying national agricultural development objectives, selecting priority areas for investment, designing effective price policies, and mobilizing resources are all critical. But for most agricultural development activities, careful project preparation in advance of expenditure is, if not absolutely essential, at least the best available means to ensure efficient, economic use of capital funds and to increase the chances of implementation on schedule. Unless projects are carefully prepared in substantial detail, inefficient or even wasteful expenditure is almost sure to result—a tragic loss in nations short of capital.

Yet in many countries the capacity to prepare and analyze projects lags. Administrators, even those in important planning positions, continually underestimate the time and effort needed to prepare suitable projects. So much attention is paid to policy formulation and planning of a much broader scope that administrators often overlook the specific

Facing page: Plowing a field in Rajasthan, India.

projects on which to spend available money and on which much development depends. Ill-conceived, hastily planned projects, virtually improvised on the spot, are too often the result.

What Is a Project?

In this book we will discuss how to compare the stream of investment and production costs of an agricultural undertaking with the flow of benefits it will produce. The whole complex of activities in the undertaking that uses resources to gain benefits constitutes the agricultural project. If this definition seems broad, it is intentionally so. As we shall see, the project format can accommodate diverse agricultural endeavors. An enormous variety of agricultural activities may usefully be cast in project form. The World Bank itself lends for agricultural projects as different as irrigation, livestock, rural credit, land settlement, tree crops, agricultural machinery, and agricultural education, as well as for multisectoral rural development projects with a major agricultural component. In agricultural project planning, form should follow analytical content.

We generally think of an agricultural project as an investment activity in which financial resources are expended to create capital assets that produce benefits over an extended period of time. In some projects, however, costs are incurred for production expenses or maintenance from which benefits can normally be expected quickly, usually within about a year. The techniques discussed in this book are equally applicable to estimating the returns from increased current expenditure in both kinds of projects.

Indeed, the dividing line between an "investment" and a "production" expenditure in an agricultural project is not all that clear. Fertilizers, pesticides, and the like are generally thought of as production expenses used up within a single crop season or, in any event, within a year. A dam, a tractor, a building, or a breeding herd is generally thought of as an investment from which a return will be realized over several years. But the same kind of activity may be considered a production expense in one project and an investment in another. Transplanting rice is a production expense. Planting rubber trees is an investment. But from the standpoint of agronomics and economics they are not different kinds of activities at all. In both cases young plants grown in a nursery are set out in the fields, and from them a benefit is expected when they mature. The only difference is the time span during which the plants grow.

Often projects form a clear and distinct portion of a larger, less precisely identified program. The whole program might possibly be analyzed as a single project, but by and large it is better to keep projects rather small, close to the minimum size that is economically, technically, and administratively feasible. Similarly, it is generally better in planning projects to analyze successive increments or distinct phases of activity; in this way the return to each relatively small increment can be

judged separately. If a project approaches program size, there is a danger that high returns from one part of it will mask low returns from another. A 100,000-hectare land settlement program may well be better analyzed as five 20,000-hectare projects if the soils and slopes in some parts are markedly different from those in others. Analyzing the whole project may hide the fact that it is economically unwise to develop some parts of the 100,000-hectare area instead of moving on to an entirely different region. When arranging for external financing or planning the administrative structure, it is sometimes convenient for planners to group several closely related projects into a single, larger "package." In these instances it may still be preferable to retain the separate analyses of individual components, in a composite of the whole, rather than to aggregate them into a single, overall analysis.

Again, all we can say in general about a project is that it is an activity for which money will be spent in expectation of returns and which logically seems to lend itself to planning, financing, and implementing as a unit. It is the smallest operational element prepared and implemented as a separate entity in a national plan or program of agricultural development. It is a specific activity, with a specific starting point and a specific ending point, intended to accomplish specific objectives. Usually it is a unique activity noticeably different from preceding, similar investments, and it is likely to be different from succeeding ones, not a routine segment of an ongoing program.

It will have a well-defined sequence of investment and production activities, and a specific group of benefits, that we can identify, quantify, and, usually in agricultural projects, determine a money value for.

If development can be pictured as a progression with many dimensions—temporal, spatial, sociocultural, financial, economic—projects can be seen as the temporal and spatial units, each with a financial and economic value and a social impact, that make up the continuum. A project is an undertaking an observer can draw a boundary around—at least a conceptual boundary—and say "this is the project." As well as its time sequence of investments, production, and benefits, the project normally will have a specific geographic location or a rather clearly understood geographic area of concentration. Probably there will also be a specific clientele in the region whom the project is intended to reach and whose traditional social pattern the project will affect.

Given the usefulness of the project format in the development process, the project has increasingly been used as a "time slice" of a long-term program for a region, a commodity, or a function such as agricultural extension. Although such projects normally have a definite beginning and end, the importance of these starting and finishing points is reduced. Such a use of the project format also makes quantification of benefits more difficult because some benefits may not be realized until subsequent phases of the program that are not included in the project. Often a project will have a partially or wholly independent administrative structure and set of accounts and will be funded through a specifically defined financial package. I hope that, after following the methodology presented

here, readers will also subject their projects to an analysis of financial results and economic justification. People are sometimes concerned that they do not have an academic definition of what a project is. There is no need to be; in practice, the definition works itself out. There are much more important aspects of project analysis to grapple with than an academic formulation of a project definition.

Plans and Projects

Virtually every developing country has a systematically elaborated national plan to hasten economic growth and further a range of social objectives. Projects provide an important means by which investment and other development expenditures foreseen in plans can be clarified and realized. Sound development plans require good projects, just as good projects require sound planning. The two are interdependent.

Sound planning rests on the availability of a wide range of information about existing and potential investments and their likely effects on growth and other national objectives. It is project analysis that provides this information, and those projects selected for implementation then become the vehicle for using resources to create new income. Realistic planning involves knowing the amount that can be spent on development activities each year and the resources that will be required for particular kinds of investment.

Project selection must always be based in part on numerical indicators of the value of costs and returns. These can often be measured through valuation at the market prices—the prices at which goods or services are actually traded. Unfortunately, however, market prices may be misleading indicators of the use and return of real resources, so governments need to look at other aspects of potential investments to judge the real effects the investments will have. For this, good project analysis is a tremendous asset, since the investment proposal can be valued to reflect the true scarcity of resources when market prices do not. (Note that by market prices we refer to the actual prices at which goods and services are traded in a generalized system of exchange, not to the particular place at which the exchange takes place. To talk of a village "market" or a wholesale "market" is to use the word in a slightly different sense. This may seem an obvious distinction, but in project analysis it does make a difference whether the "market price" is collected in the appropriate "market," and we will return to this issue later.)

Well-analyzed projects often become the vehicle for obtaining outside assistance when both the country and the external financing agency agree on a specific project activity and know the amount of resources involved, the timing of loan disbursements, and the benefits likely to be realized. But project analysis should not be confined to only those investments for which external financing will be sought. The more investments there are that can be analyzed as projects, the more likely it is that the total use of resources for development will be efficient and effective. To

concentrate a high proportion of available analytical skills on preparing projects for external assistance, and to leave investment of local resources basically unplanned, is a wasteful allocation of talent. If carefully designed and high-yielding projects are offset by essentially unplanned investments, then the net contribution to national objectives is substantially undermined.

Sound planning requires good projects, but effective project preparation and analysis must be set in the framework of a broader development plan. Projects are a part of an overall development strategy and a broader planning process; as such, they must fit appropriately. Governments must allocate their available financial and administrative resources among many sectors and many competing programs. Project analysis can help improve this allocation, but it alone cannot be relied upon to achieve the optimal balance of objectives. Within the broad strategy, analysts must identify potential projects that address the policy or production targets and priorities. Further, to make a realistic estimate about the course of a project, some idea must be gained of what other development activities will be taking place and what policies are likely to be pursued. Will employment growth make labor relatively more productive and thus more expensive to use in the project? Will input supplies be available at the time the project needs them? Will quotas be relaxed? Will food grain prices be allowed to rise? Integration of plans and projects becomes all the more important as the size of the project grows larger relative to the total economy. If the project alone is likely to have a significant effect on the availability of resources and on prices in the economy as a whole, then it must be very carefully planned in coordination with other investments and within an appropriate policy framework included in the national plan.

For the project itself, some elements used in agricultural project analysis should not be worked out in isolation by the individual analyst. All the projects being prepared and analyzed should use a consistent set of assumptions about such things as the relative scarcity of investment funds, foreign exchange, and labor. All project analyses should use the same assumptions about the social policies and objectives to be reflected in such decisions as the location of the project, the size of the landholding to be established, the amount of social services to be included, and the like.

Advantages of the Project Format

Projects carefully prepared, within the framework of broader development plans, both advance and assess the larger development effort. The project format itself is an analytical tool. The advantage of casting proposed investment decisions in the project format lies in establishing the framework for analyzing information from a wide range of sources. Because no plan can be better than the data and assumptions about the future on which it is based, the reality of the analysis to a large degree

depends on information from various sources and the considered judgments of various specialists in different areas. The project format facilitates gathering the information and laying it out so that many people can participate in providing information, defining the assumptions on which it is based, and evaluating how accurate it is.

The project format gives us an idea of costs year by year so that those responsible for providing the necessary resources can do their own planning. Project analysis tells us something about the effects of a proposed investment on the participants in the project, whether they are farmers, small firms, government enterprises, or the society as a whole. Looking at the effects on individual participants, we can assess the possible incentives a proposed project has and judge if farmers and others may successfully be induced to participate.

Casting a proposed investment in project form enables a better judgment about the administrative and organizational problems that will be encountered. It enables a strengthening of administrative arrangements if these appear to be weak and tells something of the sensitivity of the return to the investment if managerial problems arise. Careful project planning should make it more likely that the project will be manageable and that the inherent managerial difficulties will be minimal. The project format gives both managers and planners better criteria for monitoring the progress of implementation.

The project format encourages conscious and systematic examination of alternatives. The effects of a proposed project on national income and other objectives can conveniently be compared with the effects of projects in other sectors, of other projects in the same sector, or—very important—of alternative formulations of virtually the same project. One alternative can be the effects of no project at all.

Another advantage of the project format is that it helps contain the data problem. In many developing countries, national data are unavailable or are, to a substantial degree, unreliable. It is true that a project must be seen in a national context, but in many instances the direction that a country's development effort should take is well known, even if precise figures are not available. Most countries know they must increase food production even if they cannot cite reliable figures about total production or recent growth rates. By channeling much of the development effort into projects, the lack of reliable national data can be mitigated. Once the project area or clientele has been determined—once a conceptual boundary has been drawn—local information on which to base the analysis can be efficiently gathered, field trials can be undertaken, and a judgment can be made about social and cultural institutions that might influence the choice of project design and its pace of implementation. Investment can then proceed with confidence.

Because of the advantages of the project format in development planning, I would recommend that its use be extended to as many kinds of investment analysis as possible, even when this stretches the form. For projects of the production type—with clear-cut investments and easily valued costs and benefits, as is so often the case in agriculture—the

project format is of course well suited. But many kinds of activities that might otherwise be thought of as programs can also be effectively cast in project form. Rural credit activities and even agricultural education, agricultural extension, and agricultural research can be put in project form to good effect, although the benefits from these kinds of projects may be impossible to value. In these instances, the orientation of the analysis may simply be changed to that of least-cost comparisons, and the other advantages of the project format will continue to be realized. These include systematic contributions to the preparation and review of the project by a wide range of specialists, carefully specified objectives, systematic consideration of alternatives, year-by-year estimates of cost, and the opportunity to examine carefully the organizational and managerial implications.

Limitations of the Project Format

Although the project format has many advantages, the results of project analysis must be interpreted with caution. Obviously, the quality of project analysis depends on the quality of the data used and of the forecasts of costs and benefits made. Here the GIGO principle—"garbage in, garbage out"—works with a vengeance. Unrealistic assumptions about yields, acceptance by farmers, response to incentives by entrepreneurs, the trend of future prices and the relative effect of inflation upon them, market shares, or the quality of project management can make garbage out of the project analysis.

To begin with, projects will exist in a changing technical environment. For some projects the possibility of technological obsolescence will affect judgments about the attractiveness of the investment. Fortunately, in agriculture this is not often a serious problem, although in other sectors it can be.

Because future circumstances will change, we must judge the risk and uncertainty surrounding a project, and here techniques of project analysis offer only limited help. It is impossible to quantify completely the risks of a project. We can, however, note that different kinds of projects or different formulations of essentially the same project may involve different degrees of risk. These differences will affect the choice of project design. We can also test a project for sensitivity to changes in some specific element, see how the benefit produced by the project will be affected, and then judge how likely it is that such changes will occur and whether the changes in benefits will alter our willingness to proceed. We could do such "sensitivity analysis," for example, by assuming that future yields will be less than our best estimate or that future prices will be lower than the level of our most likely projection, and then decide how probable such shortfalls will be and whether we still wish to continue with the project. Sensitivity analyses that simply assume "all costs increased by 10 percent" or "all benefits lowered by 10 percent," which are easy to perform if machine computation is used, are generally of little

usefulness; tests for specific changes that can lead to decisions on project design are far superior. Techniques have been developed for more formal analysis of risk, but they have not been widely applied to agricultural projects. They rest on assigning probabilities to a range of alternative assumptions. These techniques are complex and generally require machine computation.

Project analysis is a species of what economists call "partial analysis." Normally we assume that the projects themselves are too small in relation to the whole economy to have a significant effect on prices. In many instances, however, a proposed project is relatively large in relation to a national or regional economy. In this event we must adjust our assumptions about future price levels to take account of the impact of the project itself. At best, such adjustments are approximate and may severely limit the usefulness of the measures of project worth that will be discussed in chapter 9. Much more elaborate analytical procedures than those discussed here must then be called into play—generally some form of a programming model. Such techniques were used by the World Bank to analyze development of the Indus Basin in India and Pakistan, for instance (Lieftinck, Sadove, and Creyke 1968), and have been applied to regional agricultural development programs in Mexico (Norton and Solis 1982) and Brazil (Kutcher and Scandizzo 1981), among other countries. Even in those instances, however, the partiality of the assumptions means that the results must be interpreted with care.

The greater the differences among alternative projects, the more difficult it is to use formal analytical techniques to compare them. Financial and economic analyses of the sort discussed in this book are quite good for comparing such close alternatives as two versions of an irrigation project, or even an irrigation project and a land settlement project. They are relatively good for comparing alternative projects having costs and benefits that can be valued reasonably well—for instance, a project for a food processing plant and another for irrigation. But when we wish to compare projects whose benefits can be valued rather well (such as projects to increase agricultural output, or light manufacturing projects) with projects whose benefits cannot be valued (such as education or rural domestic water supply projects), then the formal techniques can hardly be used to determine the best alternative. In such instances, the allocation between different projects must be done more subjectively and as part of an overall development plan. The usefulness of the project format in these instances is not so much in facilitating comparison between two projects as in ensuring that both projects are planned so that they can be carried out efficiently.

By and large, project analysis is more useful when it is applied to unique investment activities. Ongoing services such as police and fire protection, extension services, export promotion, and even normal education services are probably better treated as part of a program than as individual projects. The project form works best where there is a rather clear investment-return cycle and a rather clear definition of geographical area or clientele.

Another limitation of the project format is an underlying conceptual problem about valuation based on the price system. The relative value of items in a price system depends on the relative weights that individuals participating in the system attach to the satisfaction they can obtain with their incomes. They choose among alternatives, and thus the prices of goods and services balance with the values attached to these goods and services by all who participate in the market. Such a system, however, reflects the distribution of income among its participants; in the end, values trace back to existing income distribution. Project analysis takes as a premise that inequities of income distribution can be corrected by suitable policies implemented over a period of time. If such a premise is not accepted, then the whole basis of the valuation system in project analysis (and of the underlying price system upon which it rests) is called into question.

Although project analysis must consciously be placed in a broader political and social environment, in general the effects of a project on this environment can be assessed only subjectively. Often economists refer to "externalities" or side effects, such as skill creation and the development of managerial abilities, that are by-products of a project. Projects may also be undertaken to further many objectives—such as regional integration, job creation, or improving rural living conditions—beyond economic growth alone. The less subject to valuing these objectives are, the less formal are the project analysis techniques that can be used to compare them, although the project format can still be effectively used to encourage careful planning and efficiency.

Furthermore, projects are not the only development initiatives that governments may undertake. The development process calls for such measures as good price policies, carefully designed tariff policies, and participation in discussions to obtain wider market access, and none of these lends itself easily to being cast in project form.

Projects are planned and implemented in a political environment. This is as it must be, since it is the political process that enables societies to balance many, often conflicting, objectives. But questions inevitably arise about the political overtones of project analysis. Is the "national" interest the same as the "social" interest? In project planning and analysis how do we adequately incorporate such considerations as national integrity, nation building, or national defense? One objective may be to benefit disadvantaged groups or regions, but projects in which these objectives are important may not always be the most remunerative. Political leaders must respond to all sorts of pressures, and the way they weigh various tradeoffs may not lead to the same conclusions a project analyst would reach.

All this is to say that, even though the analytical methods we will discuss can be of great help in identifying which projects will increase national income most rapidly, they will not make the actual decision of project investment. That decision is one on which many, many factors other than quantitative or even purely economic considerations must be brought to bear. A settlement project and a plantation project may have

roughly similar economic benefits, but the settlement alternative may be chosen because it promises better income distribution benefits. Or, the analysis may reveal that the plantation project is more profitable and may give an idea of just how much so. Is the social benefit of the lower-paying project worth forgoing the probable future income from the higher-paying project? In the final analysis, any national investment decision must be a political act that embodies the best judgment of those responsible. The function of project analysis is not to replace this judgment. Rather, it is to provide one more tool (a very effective one, we hope) by which judgment can be sharpened and the likelihood of error reduced.

Aspects of Project Preparation and Analysis

To design and analyze effective projects, those responsible must consider many aspects that together determine how remunerative a proposed investment will be. All these aspects are related. Each touches on the others, and a judgment about one aspect affects judgments about all the others. All must be considered and reconsidered at every stage in the project planning and implementation cycle. A major responsibility of the project analyst is to keep questioning all the technical specialists who are contributing to a project plan to ensure that all relevant aspects have been explicitly considered and allowed for. Here we will divide project preparation and analysis into six aspects: technical, institutional-organizational-managerial, social, commercial, financial, and economic. These categories derive from those suggested by Ripman (1964), but alternative groupings would be equally valid for purposes of discussion.

Technical aspects

The technical analysis concerns the project's inputs (supplies) and outputs (production) of real goods and services. It is extremely important, and the project framework must be defined clearly enough to permit the technical analysis to be thorough and precise. The other aspects of project analysis can only proceed in light of the technical analysis, although the technical assumptions of a project plan will most likely need to be revised as the other aspects are examined in detail. Good technical staff are essential for this work; they may be drawn from consulting firms or technical assistance agencies abroad. They will be more effective if they have a good understanding of the various aspects of project analysis, but technical staff, no matter how competent, cannot work effectively if they are not given adequate time or if they do not have the sympathetic cooperation and informed supervision of planning officials.

The technical analysis will examine the possible technical relations in a proposed agricultural project: the soils in the region of the project and their potential for agricultural development; the availability of water, both natural (rainfall, and its distribution) and supplied (the possibilities

roughly similar economic benefits, but the settlement alternative may be chosen because it promises better income distribution benefits. Or, the analysis may reveal that the plantation project is more profitable and may give an idea of just how much so. Is the social benefit of the lower-paying project worth forgoing the probable future income from the higher-paying project? In the final analysis, any national investment decision must be a political act that embodies the best judgment of those responsible. The function of project analysis is not to replace this judgment. Rather, it is to provide one more tool (a very effective one, we hope) by which judgment can be sharpened and the likelihood of error reduced.

Aspects of Project Preparation and Analysis

To design and analyze effective projects, those responsible must consider many aspects that together determine how remunerative a proposed investment will be. All these aspects are related. Each touches on the others, and a judgment about one aspect affects judgments about all the others. All must be considered and reconsidered at every stage in the project planning and implementation cycle. A major responsibility of the project analyst is to keep questioning all the technical specialists who are contributing to a project plan to ensure that all relevant aspects have been explicitly considered and allowed for. Here we will divide project preparation and analysis into six aspects: technical, institutional-organizational-managerial, social, commercial, financial, and economic. These categories derive from those suggested by Ripman (1964), but alternative groupings would be equally valid for purposes of discussion.

Technical aspects

The technical analysis concerns the project's inputs (supplies) and outputs (production) of real goods and services. It is extremely important, and the project framework must be defined clearly enough to permit the technical analysis to be thorough and precise. The other aspects of project analysis can only proceed in light of the technical analysis, although the technical assumptions of a project plan will most likely need to be revised as the other aspects are examined in detail. Good technical staff are essential for this work; they may be drawn from consulting firms or technical assistance agencies abroad. They will be more effective if they have a good understanding of the various aspects of project analysis, but technical staff, no matter how competent, cannot work effectively if they are not given adequate time or if they do not have the sympathetic cooperation and informed supervision of planning officials.

The technical analysis will examine the possible technical relations in a proposed agricultural project: the soils in the region of the project and their potential for agricultural development; the availability of water, both natural (rainfall, and its distribution) and supplied (the possibilities

for developing irrigation, with its associated drainage works); the crop varieties and livestock species suited to the area; the production supplies and their availability; the potential and desirability of mechanization; and pests endemic in the area and the kinds of control that will be needed. On the basis of these and similar considerations, the technical analysis will determine the potential yields in the project area, the coefficients of production, potential cropping patterns, and the possibilities for multiple cropping. The technical analysis will also examine the marketing and storage facilities required for the successful operation of the project, and the processing systems that will be needed.

The technical analysis may identify gaps in information that must be filled either before project planning or in the early stages of implementation (if allowance is made for the project to be modified as more information becomes available). There may need to be soil surveys, groundwater surveys, or collection of hydrological data. More may need to be known about the farmers in the project, their current farming methods, and their social values to ensure realistic choices about technology. Field trials may be needed to verify yields and other information locally.

As the technical analysis proceeds, the project analyst must continue to make sure that the technical work is thorough and appropriate, that the technical estimates and projections relate to realistic conditions, and that farmers using the proposed technology on their own fields can realize the results projected.

Institutional-organizational-managerial aspects

A whole range of issues in project preparation revolves around the overlapping institutional, organizational, and managerial aspects of projects, which clearly have an important effect on project implementation.

One group of questions asks whether the institutional setting of the project is appropriate. The sociocultural patterns and institutions of those the project will serve must be considered. Does the project design take into account the customs and culture of the farmers who will participate? Will the project involve disruption of the ways in which farmers are accustomed to working? If it does, what provisions are made to help them shift to new patterns? What communication systems exist to bring farmers new information and teach them new skills? Changing customary procedures is usually slow. Has enough time been allowed for farmers to accept the new procedures, or is the project plan overly optimistic about rates of acceptance?

To have a chance of being carried out, a project must relate properly to the institutional structure of the country and region. What will be the arrangements for land tenure? What size holding will be encouraged? Does the project incorporate local institutions and use them to further the project? How will the administrative organization of the project relate to existing agencies? Is there to be a separate project authority? What will be its links to the relevant operating ministries? Will the staff

be able to work with existing agencies or will there be institutional jealousies? Too often a project's organization simply builds up opposition within other agencies; at the very least, the project analyst must be sure such friction is minimized. He should arrange for all agencies concerned to have an opportunity to comment on the proposed organization of the project and ensure that their views enter in the deliberation to the fullest extent possible.

The organizational proposals should be examined to see that the project is manageable. Is the organization such that lines of authority will be clear? Are authority and responsibility properly linked? Does the organizational design encourage delegation of authority, or do too many people report directly to the project director? Does the proposed organization take proper account of the customs and organizational procedures common in the country and region? Or, alternatively, does it introduce enough change in organizational structure to break out of ineffective traditional organizational forms? Are ample provisions included for managers and government supervisors to obtain up-to-date information on the progress of the project? Is a special monitoring group needed? What about training arrangements? Does the project have sufficient authority to keep its accounts in order and to make disbursements promptly?

Managerial issues are crucial to good project design and implementation. The analyst must examine the ability of available staff to judge whether they can administer such large-scale public sector activities as a complex water project, an extension service, or a credit agency. If such skills are scarce or absent, should this be reflected in a less complex project organization? Perhaps the technical analysis of the project should be consulted and the project design concentrate on fewer or less complex technological innovations. When managerial skills are limited, provision may have to be made for training, especially of middle-level personnel. In some cases expatriate managers may have to be hired, and this may raise other problems, such as the acceptance of the project manager by the local people and the loss of the experience the expatriate manager gained while working on the project when the manager leaves the country. In many instances it would be preferable if possible to design the organization of the project to avoid the need for management services of expatriates.

In agricultural projects the analyst will also want to consider the managerial skills of the farmers who will participate. A project design that assumes new and complex managerial skills on the part of participating farmers has obvious implications for the rate of implementation. If farmers with past experience limited to crop production are to become dairy farmers, enough time must be allotted for them to gain their new skills; the project design cannot assume that they will be able to make the shift overnight. There must be extension agents who can help farmers learn the new skills, and provision must be made for these agents in the organizational design and in the administrative costs of the project.

In considering the managerial and administrative aspects of project design, not only are we concerned that managerial and administrative problems will eventually be overcome, but that a realistic assessment is made of how fast they will be resolved. The contribution an investment makes to creating new income is very sensitive to delays in project implementation.

Social aspects

We have mentioned the need for analysts to consider the social patterns and practices of the clientele a project will serve. More and more frequently, project analysts are also expected to examine carefully the broader social implications of proposed investments. We have noted proposals to include weights for income distribution in the formal analytical framework so that projects benefiting lower-income groups will be favored. In the analytical system outlined in this book, such weights are not incorporated, so it is all the more important in the project design that explicit attention be paid to income distribution.

Other social considerations should also be carefully considered to determine if a proposed project is as responsive to national objectives as it can be. There is a question about creating employment opportunities that is closely linked to, though not quite the same as, the question of income distribution. For social reasons, many governments want to emphasize growth in particular regions and want projects that can be implemented in these regions. The project analyst will want to consider carefully the adverse effects a project may have on particular groups in particular regions. In the past, the introduction of high-yielding seed varieties and fertilizers, coupled with the easy availability of tractors, has led to displacement of tenant farmers and has forced them into the ranks of the urban unemployed. Can the project be designed to minimize such effects, or be accompanied by policy changes that will? Changes in technology or cropping patterns may change the kind of work done by men and women. In some areas the introduction of mechanical equipment or of cash crops has deprived women of work they needed to support their children. Will a proposed project have such an adverse effect on the income of working women and their families?

There are also considerations concerning the quality of life that should be a part of any project design. A rural development project may well include provisions for improved rural health services, for better domestic water supplies, or for increased educational opportunities for rural children. Project analysts will want to consider the contribution of alternative projects or other designs of essentially the same project in furthering these objectives.

Those designing or reviewing projects will also want to consider the issue of adverse environmental impact (Wall 1979; Lee 1982). Irrigation development may reduce fish catches or increase the incidence of schistosomiasis in regions where this snail-transmitted disease is endemic, and

waste from industrial plants may pollute water. Project sites may be selected with an eye to preserving notable scenic attractions or to preserving unique wildlife habitats. It is far better to ensure preservation of the environment by appropriate project design than to incur the expense of retrofitting technology or reclaiming land after an environmentally unsound project has been implemented.

Commercial aspects

The commercial aspects of a project include the arrangements for marketing the output produced by the project and the arrangements for the supply of inputs needed to build and operate the project.

On the output side, careful analysis of the proposed market for the project's production is essential to ensure that there will be an effective demand at a remunerative price. Where will the products be sold? Is the market large enough to absorb the new production without affecting the price? If the price is likely to be affected, by how much? Will the project still be financially viable at the new price? What share of the total market will the proposed project supply? Are there suitable facilities for handling the new production? Perhaps provision should be included in the project for processing, or maybe a separate marketing project for processing and distribution is in order (Austin 1981). Is the product for domestic consumption or for export? Does the proposed project produce the grade or quality that the market demands? What financing arrangements will be necessary to market the output, and what special provisions need to be made in the project to finance marketing? Since the product must be sold at market prices, a judgment about future government price supports or subsidies may be in order.

On the input side, appropriate arrangements must be made for farmers to secure the supplies of fertilizers, pesticides, and high-yielding seeds they need to adopt new technology or cropping patterns. Do market channels for inputs exist, and do they have enough capacity to supply new inputs on time? What about financing for the suppliers of inputs and credit for the farmers to purchase these supplies? Should new channels be established by the project or should special arrangements be made to provide marketing channels for new inputs?

Commercial aspects of a project also include arrangements for the procurement of equipment and supplies. Are the procurement procedures such that undue delays can be avoided? Are there procedures for competitive bidding to ensure fair prices? Who will draw up the specifications for procurement?

Finally, there are the two aspects of project analysis that are the primary concerns of this book, the financial and the economic.

Financial aspects

The financial aspects of project preparation and analysis encompass the financial effects of a proposed project on each of its various partici-

pants. In agricultural projects the participants include farmers, private sector firms, public corporations, project agencies, and perhaps the national treasury. For each of these, separate budgets must be prepared, along lines suggested in chapters 4 through 6. On the basis of these budgets, judgments are formed about the project's financial efficiency, incentives, creditworthiness, and liquidity.

A major objective of the financial analysis of farms is to judge how much farm families participating in the project will have to live on. The analyst will need budget projections that estimate year by year future gross receipts and expenditures, including the costs associated with production and the credit repayments farm families must make, to determine what remains to compensate the family for its own labor, management skills, and capital. Part of the income the family will receive may be in food that is consumed directly in the household, so a judgment must be made about this quantity and its value. Even if a family realizes a considerable increase in income or "net incremental benefit" by participating in the project—as a result, say, of borrowing to purchase fertilizers to increase rice production—its absolute income may still be so low that nearly all of the incremental production is consumed in the household. Financial analysis must judge whether the family will then have sufficient cash to repay the production credit for fertilizer. If not, the analyst may have to make a policy judgment about how much to subsidize families with very low incomes.

The farm budget becomes the basis for shaping the credit terms to be made available. The analyst must judge whether farmers will need loans to finance on-farm investment (and if so, what proportion the farmers should invest from their own resources) or to meet some production costs, and whether seasonal short-term credit should be provided for working capital to finance inputs and pay for hired labor. In tree-crop projects with long development periods, such as those for oil palm or citrus, the analyst must judge whether farmers will have adequate income to live on during the period before the trees begin to bear, or whether special financing arrangements must be made to sustain them. The objective of all these judgments is to shape credit terms that will be generous enough to encourage farmers to participate in the project, yet be stiff enough that the society as a whole can capture fairly promptly a share of the benefit from the increased production. This benefit can, in turn, be used to hasten growth by relending it to other farmers or by reinvesting it elsewhere in the economy.

The analysis of farm income will also permit assessment of the incentives for farmers to participate in the project. What will be the probable change in farm income? What will be the timing of this change? How likely are price changes or fluctuations that could affect farm income severely enough that farmers will refuse to run the risk of participating in the project? What will be the effect of subsidy arrangements on farm income, and what changes in government policy might affect the income earned by farmers? Will new subsidies be needed to provide sufficient incentive for the project to proceed?

A similar group of considerations applies to the financial analysis of private firms involved in the project. Will they have capital for expanding facilities? Will they have the working capital needed to carry inventories of farm supplies or stocks of processed goods awaiting sale? What return will the firms realize on their capital investment, and is this sufficiently attractive?

An analysis of the financial aspects of the project's administration will also be needed. What investment funds will the project need and when? What will be the operating expenses when the project is under way? Will these expenses depend on budget allocations or will the project produce sufficient revenue to cover its administrative costs? Will changes in government policy be needed to finance the project, such as water charges levied in a new irrigation project? What about salary scales for project personnel? How will replacement of equipment be financed?

Finally, the fiscal impact of some projects will need to be considered. Will the increased output yield significant new tax revenues, perhaps from an export tax? Will new subsidies be needed to encourage farmers to participate, and how much will subsidies have to grow as project implementation proceeds? If the administrative costs of the project are not to be met from revenues, how will this affect the national budget in the future? If the project investment is to be financed by a grant or by borrowing from abroad, while the operation and maintenance cost is to be financed from domestic resources, how will this affect the treasury?

The methodology of discounted cash flow discussed in chapters 9 and 10 shows the way in which this financial analysis customarily is set up and the usual elements included in the cost and benefit streams. The methodology enables an estimate of the return to the equity capital of each of the various project participants, public or private. It is then a policy decision whether to change that return by income taxes, special lending terms, price subsidies, or any of the other tools open to society.

Economic aspects

The economic aspects of project preparation and analysis require a determination of the likelihood that a proposed project will contribute significantly to the development of the total economy and that its contribution will be great enough to justify using the scarce resources it will need. The point of view taken in the economic analysis is that of the society as a whole.

The financial and economic analyses are thus complementary—the financial analysis takes the viewpoint of the individual participants and the economic analysis that of the society. But, because the same discounted cash flow measures (discussed in chapter 9) are applied in the financial analysis to estimate returns to a project participant and in the economic analysis to estimate returns to society, confusion between the two analyses easily arises. There are three very important distinctions between the two that must be kept in mind. These qualifications are summarized here and are taken up in greater detail later.

First, in economic analysis taxes and subsidies are treated as transfer payments. The new income generated by a project includes any taxes the project can bear during production and any sales taxes buyers are willing to pay when they purchase the project's product. These taxes, which are part of the total project benefit, are transferred to the government, which acts on behalf of the society as a whole, and are not treated as costs. Conversely, a government subsidy to the project is a cost to the society, since the subsidy is an expenditure of resources that the economy incurs to operate the project. In financial analysis such adjustments are normally unnecessary; taxes are usually treated as a cost and subsidies as a return.

Second, in financial analysis market prices are normally used. These take into account taxes and subsidies. From these prices come the data used in the economic analysis. In economic analysis, however, some market prices may be changed so that they more accurately reflect social or economic values. These adjusted prices are called "shadow" or "accounting" prices and in the analytical system recommended here are efficiency prices, as noted earlier. In both financial and economic analysis projected prices are used, so both rely to a substantial extent on what are, in effect, hypothetical prices.

Third, in economic analysis interest on capital is never separated and deducted from the gross return because it is part of the total return to the capital available to the society as a whole and because it is that total return, including interest, that economic analysis is designed to estimate. In financial analysis, interest paid to external suppliers of money may be deducted to derive the benefit stream available to the owners of capital. But interest imputed or "paid" to the entity from whose point of view the financial analysis is being done is not treated as a cost because the interest is part of the total return to the equity capital contributed by the entity. Hence, it is a part of the financial return that entity receives.

The methodology of comparing costs and benefits discussed in chapters 9 and 10 is the same for either an economic or a financial measurement of project worth, but what is defined as a cost and what is considered a benefit are different. For the moment, it is enough to recognize that there is a difference between economic and financial analysis; we will discuss the differences in detail later.

Policymakers must be concerned about the investment of scarce capital resources that will best further national objectives. This is true whether the resources committed are being invested by the government directly or by individuals within the economy. The techniques of economic analysis presented here help identify those projects that make the greatest contribution to national income. The economic analysis in general allows for remuneration to labor and other inputs either at market prices or at shadow prices that are intended in the system recommended here to better approximate efficiency prices or "opportunity costs"—the amount we must give up if we transfer a resource from its present use to the project. The remainder is then compared with the capital stream necessary for the project. Those projects with the best

return to capital, given the total resources available, are then selected for implementation. Inherent in this approach is the assumption that capital is the most important limit to faster economic growth. What is not implicit in the approach is that capital alone causes economic growth. All the productive factors combined in a project contribute to the new income created, but the methods we will be discussing do not address themselves to the question of what the proportionate contribution of each factor is.

We will apply the methods discussed here in economic (but not financial) analysis in such a way that the economic analysis does not itself address the issue of income distribution. Although the analysis will determine the amount of the income stream generated over and above the costs of labor and other inputs, it does not specify who actually receives it. Part of a project's benefit is usually taken through taxes for purposes outside the project. Part is generally made available to compensate capital owners (including governments) for the use of their money. Part may become the basis of an indirect transfer of income, as is the case if farmers benefiting from a land settlement project are charged less than the full cost of establishing their holdings. The economic analysis applied in this book is silent about such distribution. Once the analyst knows what the more economically remunerative alternatives are likely to be, however, he can choose those that have better effects on income distribution or other social objectives. Although the formal economic analysis will not decide issues of income distribution, the final decision on project investment will be an informed one that is then made in accord with views about income distribution.

Many economists prefer analytical systems that explicitly include income distribution weights. They note that the system outlined here accepts in its formal structure the income distribution as it exists in a society and does not distinguish projects that have the most desirable effects on income distribution. They argue that simply choosing projects subjectively from among the higher-yielding alternatives is not enough. Systems using income distribution weights are used infrequently, however, and most project investment decisions follow the general practice recommended here. Even economists who prefer using income distribution weights often recommend applying them only to that small fraction of projects in which there is reason to believe the weights might change an investment decision. Readers wishing to consult a fuller treatment of income distribution weights in project analysis may turn to Little and Mirrlees (1974) and Squire and van der Tak (1975).

Because economic analysis of a project as applied here tells us nothing about income distribution, it also tells us nothing about capital ownership. The value of a capital asset arises from the right to receive the future income the asset generates. Since our method of economic analysis does not specify who in the economy is to receive the income that a project earns, it does not address the question of who owns the capital. Economic measures of project worth reached by means of the analytical system outlined here help determine the most attractive alternative from

the society's standpoint when the objective of the analysis is to increase national income. In this analytical frame, projects are equally valid whether the capital is to come from public revenue or private sources, whether there are income taxes or not, and whether the project is to be operated by public agencies or by individuals on their own behalf. In a manner analogous to the approach taken for income distribution, governments may then choose from economically remunerative projects those that lead to higher reinvestment and, hence, faster growth.

Some economists, however, take economic growth generated by investment, not income regardless of whether it is consumed or invested, as contituting at least part of their formal objective. If that is the case, then the source of the capital for a project makes a difference, as does who receives the benefits. A project financed by private sources that will consume all of the benefits will be less economically valuable than one in which all benefits accrue to a private individual who reinvests everything. Also, both will have values different from that of an identical project in which the benefit accrues to the government. As with income distribution weights, systems that weight capital sources or the investment use of benefits become quite complex. Again, the reader may refer to Little and Mirrlees (1974) and Squire and van der Tak (1975).

The Project Cycle

There tends to be a natural sequence in the way projects are planned and carried out, and this sequence is often called the "project cycle." As was the case with aspects of project analysis, there are many ways—all equally valid—in which this cycle may be divided. Here we will divide it into identification, preparation and analysis, appraisal, implementation, and evaluation. The sequence is adapted from an article by Baum (1978).

Identification

The first stage in the cycle is to find potential projects. There are many, many sources from which suggestions may come. The most common will be well-informed technical specialists and local leaders. While performing their professional duties, technical specialists will have identified many areas where they feel new investment might be profitable. Local leaders will generally have a number of suggestions about where investment might be carried out. Ideas for new projects also come from proposals to extend existing programs. A program to develop water resources will probably lead to suggestions of additional areas for irrigation. An existing land settlement program will probably generate suggestions of new areas for settlement.

Suggestions for new projects usually arise because some agricultural products are in short supply—or will be in a few years if production is not expanded or imports increased. The analysis may be based on general

knowledge or upon a more systematic examination of market trends and import statistics. In addition, many countries have development banks intended to encourage growth of domestic industry. Often local firms will come to these banks with food processing proposals for which they are seeking finance.

Such project-by-project approaches may overlook important potential initiatives in agricultural development. Most developing countries have an economic development plan of some formality that identifies sectors to be given priority and areas where investment is needed. These generalized areas for priority are too vague to become the basis of investment themselves, but they lead to specific projects in crop or livestock production, land settlement, irrigation, food processing, expansion of export crop production, and the like. In the process of preparing an economic development plan, specific suggestions for projects usually will have come from the operating agencies responsible for project implementation, and these agencies may be encouraged to proceed with detailed project preparation.

Frequently, a separate sector survey of the current situation in agriculture will indicate what initiatives are needed. Such surveys may be undertaken with the help of an international agency or some agency for bilateral assistance. The sector survey will examine the current status of agriculture, project future needs for agricultural products over the next decade or so, and consider programs to improve the quality of rural life. It will examine prospects for expanding agricultural exports by considering potential increases in production and the outlook for marketing possibilities, and it will identify the gaps in existing plans and programs. The survey will probably generate suggestions about new areas for investment and the relative priority to be given different initiatives. It may even identify specific projects, especially larger ones, that merit consideration for future investment.

Occasionally one hears that there is a lack of projects available for investment in developing countries. Usually there is no shortage of proposals for projects that have been identified. But there may be a shortage of projects prepared in sufficient detail to permit implementation.

Preparation and analysis

Once projects have been identified, there begins a process of progressively more detailed preparation and analysis of project plans. This process includes all the work necessary to bring the project to the point at which a careful review or appraisal can be undertaken, and, if it is determined to be a good project, implementation can begin. In the preparation and analysis of projects, consideration will be given to each of the aspects discussed earlier.

The usual first step in project preparation and analysis is to undertake a feasibility study that will provide enough information for deciding whether to begin more advanced planning. The detail of the feasibility study will depend on the complexity of the project and on how much is

already known about the proposal. Quite often a succession of increasingly detailed feasibility studies will be needed. The feasibility study should define the objectives of the project clearly. It should explicitly address the question of whether alternative ways to achieve the same objectives may be preferable, and it will enable project planners to exclude poor alternatives. The feasibility study will provide the opportunity to shape the project to fit its physical and social environment and to ensure that it will be high yielding.

Even at this early stage, the kind of financial and economic analyses discussed in this book should be brought into play. As projects are planned in greater and greater detail, the investment of time and money becomes more and more substantial, and the expectations of vested interests continue to grow. Being faced only at a late stage in the planning process with the decision to accept or reject a project on financial or economic grounds is obviously an uncomfortable position to be in. Far better that the financial and economic analyses enter early in the planning process, so that the feasibility studies introduce these aspects in the project plan.

The staff needed to work on feasibility studies will depend on how complex the studies are. To start, a single staff member may make a preliminary estimate in a relatively short time. Later the services of a small team, or perhaps outside consultants, may be engaged.

Once the feasibility studies have indicated which proposed project will likely be worthwhile, detailed planning and analysis may begin. By this time the less promising alternatives will have been eliminated, but even at this point the selected project will continue to be redefined and shaped as more and more becomes known. This is the stage at which detailed studies will commence—the carefully done soil surveys, the detailed hydrological analyses, the thorough examination of cropping patterns, the month-by-month estimates of labor requirements, the detailed farm budgets, and so forth. Again, all the aspects of analysis noted in the last section must be considered and correlated so that realistic estimates can be made of how the project might be implemented and of its likely income-generating capacity.

Detailed planning takes time, often a year or two or longer for complex agricultural projects. It may also be quite expensive. In agriculture, preparing the detailed project plan may well cost 7 to 10 percent of the total project investment. Yet thorough preparation increases a project's efficiency and helps ensure its smooth implementation in the future, so that the additional time and money required will probably be returned many times over by the increased return from the investment. Hastily prepared, superficial analyses will very likely yield projects that fall behind schedule, have lower returns, and waste scarce resources.

Preparation of the plan should itself be planned so that delays can be avoided and resources conserved. The timing of special studies needs to be considered, and the services of outside consultants should be scheduled so they will be available when needed—but not before the consultants' specialized knowledge can be used. The project may be prepared

by a special team assembled for the purpose and given sufficient time and resources, or it may be prepared by a consulting firm or a technical assistance agency such as the Investment Centre of the Food and Agriculture Organization (FAO).

Appraisal

After a project has been prepared, it is generally appropriate for a critical review or an independent appraisal to be conducted. This provides an opportunity to reexamine every aspect of the project plan to assess whether the proposal is appropriate and sound before large sums are committed. The appraisal process builds on the project plan, but it may involve new information if the specialists on the appraisal team feel that some of the data are questionable or some of the assumptions faulty. If the appraisal team concludes that the project plan is sound, the investment may proceed. But if the appraisal team finds serious flaws, it may be necessary for the analyst to alter the project plan or to develop a new plan altogether.

If a project is to be financed by an international lending institution such as the World Bank or by a bilateral assistance agency, such an external lender will probably want a rather careful appraisal even if it has been closely associated with earlier steps in the project cycle. The World Bank, for example, routinely sends a separate mission to appraise proposed projects for which one of its member governments intends to borrow.

Implementation

The objective of any effort in project planning and analysis clearly is to have a project that can be implemented to the benefit of the society. Thus, implementation is perhaps the most important part of the project cycle. It is also clear, however, that considerations of implementation and project management are far too extensive for discussion here. Yet there are some aspects of implementation that are of particular relevance to project planning and analysis. The first, obviously, is that the better and more realistic a project plan is, the more likely it is that the plan can be carried out and the expected benefit realized. This emphasizes once again the need for careful attention to each aspect of project planning and analysis.

Second, project implementation must be flexible. Circumstances will change, and project managers must be able to respond intelligently to these changes. Technical changes are almost inevitable as the project progresses and more is known about soils, their response to nitrogen applications, susceptibility to waterlogging, and the like. Price changes may necessitate different cropping patterns or adjustments in inputs. Other changes in the project's economic or political environment will alter the way in which it should be implemented. The greater the uncertainty of various aspects of the project, or the more innovative and novel

the project is, the greater the likelihood that changes will have to be made. Even as project implementation is under way, project managers will need to reshape and replan parts of the project, or perhaps the entire project. All of the general considerations we have discussed, as well as the analytical tools we will take up in detail in the following chapters, must be brought into play once again. Implementation is a process of refinement, of learning from experience—in effect, it is a kind of "mini-cycle" within the larger project cycle we have outlined.

Project analysts generally divide the implementation phase into three different time periods. The first is the investment period, when the major project investments are undertaken. In agricultural projects this usually extends three to five years from the start of the project. If the project is to be financed with the assistance of a loan from an external financing agency, the investment period may coincide with the agency's period for loan disbursements. Then, as its production builds up, the project is spoken of as being in the development period. This often takes an additional three to five years, but it may be extended if the project involves cattle herds, tree crops, or other investments with long gestation. The duration of the development period reflects not only physical factors but also the rate of adoption at which farmers take up new techniques. Once full development is reached, it continues for the life of the project. Usually the project life is keyed to the normal life of the major asset, although for practical reasons a project life rarely exceeds twenty-five to thirty years. Both the financial and economic analyses of the project relate to this time horizon.

Evaluation

The final phase in the project cycle is evaluation. The analyst looks systematically at the elements of success and failure in the project experience to learn how better to plan for the future. Evaluation is not limited only to completed projects. It is a most important managerial tool in ongoing projects, and rather formalized evaluation may take place at several times in the life of a project. Evaluation may be undertaken when the project is in trouble, as the first step in a replanning effort. It may be appropriate when a major capital investment such as a dam is in place and operating, even though the full implementation of the plan to utilize the water and power is still under way. Careful evaluation should precede any effort to plan follow-up projects. And, finally, evaluation should be undertaken when a project is terminated or is well into routine operation.

Evaluation may be done by many different people. Project management will be continuously evaluating its experience as implementation proceeds. The sponsoring agency—perhaps the operating ministry, the planning agency, or an external assistance agency—may undertake evaluation. In large and innovative projects, the project's administrative structure may provide a separate evaluation unit responsible for monitoring the project's implementation and for bringing problems to the

attention of the project's management. Often the evaluation unit will include persons with planning skills who enable the unit to take part in any necessary replanning. The evaluation unit may also be responsible for planning follow-up projects.

In many instances, the project's management or the sponsoring agency will want to turn to outside evaluators. University staff may be well suited to undertake the task. Whoever does the evaluation will want to read the relevant documents carefully and then have extensive conversations with those who have had a part in the project—planners, project managers, operating staff, farmers participating in the project, or local people affected by the project.

The extent to which the objectives of a project are being realized provides the primary criterion for an evaluation. The objectives cannot be accepted uncritically, however; the inquiry should consider whether the objectives themselves were appropriate and suitable. The evaluators will want to know if these goals were made clear to the planners and to project management.

The project plan should be reviewed to see if it was an appropriate one in light of the objectives set forth. Each objective should be examined to determine whether it was considered carefully and whether appropriate provision for it was made in the project plan. Was the technology proposed appropriate? Were the institutional, organizational, and managerial arrangements suited to the conditions? Were the commercial aspects properly considered? Were the financial aspects carefully worked out on the basis of realistic assumptions, and were the economic implications properly explored? How did the project in practice compare with each aspect of the project analysis?

The evaluation should consider the response of project management and the sponsoring agencies to changing circumstances. Did management respond quickly enough to changes? Was its response carefully considered and appropriate? Did the institutional and organizational structure in the project permit a flexible response? How could the project's structure be altered to make the response to change more flexible and appropriate in the future?

From the evaluation should come carefully considered recommendations about how to improve the appropriateness of each aspect of the project design so that plans for project implementation can be revised if the project is ongoing and so that future projects can be better planned if the project evaluated has been completed.

Accuracy of Agricultural Project Analyses

Since agricultural project analyses are intended to become the basis for investment decisions, just how accurately do they foretell project results?

The World Bank systematically reviews the performance of projects for which it lends and publishes the results annually. These reviews

generally are undertaken at the end of the implementation phase of the project. The most recent report, from which this section draws extensively, reviewed thirty-two agricultural projects for which performance audits were completed in 1980 (World Bank 1981*a*). Although the particular projects reviewed by no means constitute a random sample, the results of the review confirm earlier trends and may be taken as generally indicative of all agricultural projects the World Bank finances. The projects included those for credit, irrigation, tree crops, fisheries, food crop production, livestock, storage, drought relief, and technical assistance.

Economic effects

Economic rates of return had been calculated at the time of appraisal for twenty-four of the projects included in the 1981 review and were reestimated at the time of the performance audit. (The other eight projects were either canceled before implementation or were of a nature—such as drought relief—that no rate of return was calculated.) The reestimates, of course, were done at the end of the implementation phase and so still included projections for the balance of the project life. Fourteen had rates of return that were within 2 percent of the rate estimated at appraisal or were greater than the appraisal estimate, and ten fell more than 2 percent below the rate of return estimated at appraisal. Of the twenty-four projects, nineteen had reestimated rates of return at the time of the review at or above 10 percent, a minimum acceptable rate in most developing countries. The rates of return alone, however, can be somewhat misleading. Several projects varied substantially from what was anticipated at the time of appraisal, but the variations were offsetting. One project that had an acceptable rate of return when reestimated at the time of the performance audit, for example, increased food grain output only about half as much as anticipated, but increases in grain prices offset the production shortfall and gave the project an acceptable rate of return.

For all projects taken together, the weighted reestimated return was 20 percent, well in line with the estimates of earlier years. Credit projects performed the best. They had an average rate of return of 26 percent, the lowest cost overruns and lower than average time overruns, and a clear advantage in reaching poor farmers. The largest subgroup, irrigation projects, had an average rate of return of 22 percent. In line with the results of previous surveys, "decentralized, small-scale groundwater and lift irrigation projects where each farmer develops his own potential were relatively smoothly implemented, resulted in lower costs per hectare, and proved extremely profitable. On the other hand, larger, centralized projects supported by detailed studies and designs and implemented by specialized agencies were beset with problems, were completed late and at much higher costs, resulted in high costs per hectare developed, and proved modestly profitable" (World Bank 1980, p. 29). The tree-crop projects had reestimated returns of 17 percent, substantially in line with the consistently good performance noted for this kind

of project in earlier years. In the five projects that had unacceptable rates of return, the failure could generally be traced to a combination of inappropriate technology and poor management.

Effect on incomes of rural poor

The World Bank has been particularly pleased that performance reviews of the projects it finances demonstrate that agricultural projects focusing on small farmers and the rural poor perform as well as other projects in the sector. The 1980 review showed that rural development projects—those specifically designed to reach large numbers of small farmers and the rural poor—had an average return of 17 percent compared with the average of 20 percent for all other kinds of agricultural projects. "They have also reached ten times as many farmers per project, at a fraction of the cost of serving medium and larger farmers. Although the absolute amount of the income increases obtained through small farmer projects were a fraction of those received by medium and larger farmers, they were larger in relative terms . . ." Because they were received by so many farmers, "they had a substantial impact on income distribution" (World Bank 1980, p. 18).

Implementation experience

Of the thirty-two projects reviewed in 1981, only five were completed without delay or with delays of 10 percent or less. (This is much below the experience reported in earlier years, when about a third of the projects were completed on time.) Of the twenty-seven projects experiencing serious delays, fourteen were completed within 50 percent more time, six were completed in from 50 to 100 percent more time, and seven took more than twice as long to complete as scheduled at appraisal.

The experience of cost increases paralleled that of time delays. The average cost increase was 29 percent. Of the thirty-two projects, only twelve were completed with cost increases of 10 percent or less, five were within the range of 10 to 59 percent cost overrun, six were in the range of 50 to 100 percent overrun, and five cost twice or more the appraisal estimate.

The major reason for delay, which affected eight projects, was poor performance by executing agencies or contractors. The second most common cause, which affected six projects, was delay caused by bidding and procurement procedures. The third most common cause was delay due to unanticipated technical problems. As had been the experience in earlier reviews, the most common reasons for cost increases were general price inflation and underestimation of unit costs at appraisal, but other reasons included increases in the scope of a project and in the total number of input units required. Delays in project implementation aggravated the effects of inflation.

Among subsector averages for timing of completion, tree-crop projects on the whole were completed on time or with very little delay, followed

by credit projects, with an average time overrun of 31 percent, and livestock and irrigation projects, with an average delay of about 50 percent. The most serious delays were encountered in emergency rehabilitation projects, which took about twice as long as anticipated, and in technical assistance projects, which took 78 percent longer on the average than planned. No regional concentration of implementation delays was apparent.

The incidence of cost increases by subsector showed that the largest increases were in irrigation projects, which had an average cost overrun of 71 percent, an experience in line with that of earlier reviews. Time and cost overruns were thus both substantial in irrigation. Agricultural credit, area development, emergency relief and rehabilitation, and technical assistance projects were completed without, or with minor, cost increases; livestock projects had moderate increases; and tree-crop projects had substantial cost increases, on average 57 percent.

Of the thirty-two projects reviewed, twenty-seven were changed, formally or informally, during implementation. The most important causes were poor or incomplete original design, which affected fifteen cases; changes in government policies and strategies, which affected eleven cases; beneficiary preferences different from those anticipated, which affected seven cases; and impending cost overruns, which affected seven cases. Most projects were affected by a combination of these factors.

Shortcomings in design appear to have been a result of projects' being approved without sufficient preparation. Not all project changes during implementation, however, are undesirable or avoidable. Some projects are designed to be of a pilot nature, and in other projects changes in the price environment lead logically to changes in the mix of products. As the review noted, "project design should be sufficiently well developed to allow for immediate and straightforward project implementation but flexible enough to allow for adaptation without causing undue delay, wasted expenditures, or cost increases, all of which might reduce" the benefit of a project (World Bank 1981*a*, p. 34).

Why Agricultural Project Analyses Prove Wrong

When an agricultural project analysis proves to be a poor predictor of the actual outcome of a project, it may be that the project design or implementation is at fault, or it may be that the project analyst has done a poor job of incorporating a good project design in an analytical framework.

Problems of project design and implementation

The same World Bank performance audits used in the previous section to judge the accuracy of agricultural project analyses in estimating economic returns also examine the reasons for poor performance (World Bank 1980 and 1981*a*). In the most recent of these reviews and in an

earlier summary of project experience prepared by Olivares (1978), the most common reasons agricultural projects run into problems of implementation may be grouped into five major categories: (1) inappropriate technology; (2) inadequate support systems and infrastructure; (3) failure to appreciate the social environment; (4) administrative problems, including those of the project itself and of the overall administration within the country; and (5) the policy environment, of which the most important aspect is producer price policy.

INAPPROPRIATE TECHNOLOGY. Given the use and availability of land in most developing countries, increased crop production generally must depend on greater crop yields rather than on area extension. Thus, improved technology is a key element in most agricultural projects. Among the thirty-two projects in the 1981 review, as many as twenty-two depended on technological packages substantially new to the farmers in the project area. The introduction of new technology was concentrated in irrigation, tree-crop, rural development, and fisheries projects.

New technologies included a range of innovations. For irrigation projects, a farm input package with water as the main input was followed by improved seeds and further complemented by fertilizers and sometimes other inputs and improved cultural practices. For tree-crop projects, innovations took the form of improved cultural practices and equipment, early-maturing and high-yielding hybrids, and chemical instead of manual weed control. Rural development projects introduced farm input packages similar to those for irrigation; livestock projects emphasized pasture improvement; fisheries projects introduced improved fishing techniques and boats and equipment; and the storage project provided for modernized grain storage, pest control, and transport.

In fifteen of the projects reviewed, information was available about the effect of the technological innovation. In general, new technology was successful; eleven projects achieved or surpassed target yields. The major success factors appear to have been the appropriateness of the technology proposed for the given local conditions, the complementarity of recommended inputs, and the strength of the support systems (including research and extension to adapt the offered technologies to suit changing circumstances; see the section on infrastructure and support systems, below). In other projects, poor performance could be traced to inappropriate technology. In one project that failed to achieve the target yield, the failure of small farmers to apply more fertilizer was attributed to their desire to minimize risk by maximizing the return on a given investment rather than the return per hectare. In another project, farmers were ready to apply selected low-risk, productivity-raising inputs but not the entire package of recommended cultivation techniques. High density and early sowing, in particular, were largely rejected. Farmers preferred to avoid risk by staggering sowing dates and planting a larger number of low-density plots. The review concluded that "new technologies for dry farming should be more risk-reducing than those for irrigated

farming where assured water supply eliminates much of the usual risk" (World Bank 1981*a*, p. 26).

INFRASTRUCTURE AND SUPPORT SYSTEMS. Of the thirty-two projects reviewed in 1981, twenty-eight could be viewed as part of an essential chain of support systems and infrastructure. The links in the chain include the relevant research, extension services, credit availability, input supply, and product markets; the importance of the chain lies in the introduction of technical packages, an essential element in most agricultural projects. These packages must first be developed and tested through research, adapted to the ecological conditions found in the project, and then delivered to the farmers through an adequately staffed, qualified, and motivated extension service that can then provide feedback for further research. In most cases, farmers do not have sufficient funds to purchase the recommended packages, and credit has to be made available. The input supply has to be organized, and this includes introduction of improved high-yielding varieties, provision of better livestock breeds, and the strategic location of stores where fertilizers, pesticides, and machinery such as pumps and their spare parts are available. Finally, the marketing of farm produce has to be organized in a manner that provides sufficient incentives to producers and avoids costly losses.

As may be expected, the content and detail of the support systems and infrastructure vary widely from project to project. In the projects reviewed, marketing systems received the most frequent attention (twenty out of twenty-eight projects), research support was given significant emphasis (seventeen projects), and credit and extension support received equal treatment (about one-half of the twenty-eight projects). Input supply systems received the least attention (one-third of the projects).

Deficiencies in the back-up research component were noted at appraisal in eight projects; in all cases a research component was included in the project, or arrangements were made for supporting research to be undertaken by an appropriate research group. In six of the eight projects, the research arrangements proved effective. In two cases, the projects suffered from lack of specific research, although both of these had included a research component in the original project design.

A major problem in agricultural and rural development projects is organizing farmers efficiently to provide them services, especially in their adapting new technology. The appropriate organization of farmers into self-help schemes is especially difficult, and the record of cooperatives has not been good. There are no easy solutions to these problems. A critical factor is to recognize at the project design stage that the small farmer will not take risks that could involve losing his livelihood and that some form of organizing farmers into self-help groups is essential to economical provision of government service.

Extension services were to be provided by the project unit in nine projects included in the 1981 review; in all but one of these the national extension service was judged to be inadequate. In general, these exten-

sion efforts were effective, but in two projects the extension effort failed to reach a minimum level of performance. In one project centered on grain production, output increased by only half the amount projected at appraisal. In the other, poor administration, including a failure to provide adequate extension, combined with poor design and unfavorable government policies to produce a negative return.

Credit was the major instrument for development in thirteen of the twenty-eight projects. It was used to promote a technical package in eight projects and other investment expenditures in the remaining five. The balance of the projects, with one exception, were clearly judged not to require credit.

Only a single input was supplied through the project in a number of cases, the full complement being provided in others. For the most part, inputs were supplied by the project units in estate projects where production was under full control of the project unit, or where small growers received credit in kind and were expected to follow specified production practices. In other projects that had an input supply component, the private sector met the needs.

Lack of marketing facilities is among the most difficult factors to provide for or change through projects directed mainly toward production. The principal marketing component in the projects was for the project unit to purchase the output of small producers. One project provided credit to market centers and cooperatives so that they could in turn provide advances to farmers for production and living expenses. One fisheries project provided cold storage facilities to improve marketing. Of the twenty-eight projects where infrastructure and support systems were central, only two were judged at audit to have been affected by lack of marketing facilities.

FAILURE TO APPRECIATE THE SOCIAL ENVIRONMENT. Sometimes the technical aspects of a project may be fairly well foreseen, but the social effects inadequately assessed. In one West African rice intensification project, progress was initially much slower than anticipated. A study revealed that in this area rice was produced by women, but that the credit needed for new inputs was channeled through institutions of which only men were members—and the men were not about to borrow for a woman's crop. When the national credit agency set up credit channels that could lend directly to women, implementation accelerated markedly.

In another African project, in an area of traditional extended family groupings a limit was established on individual loans for crop intensification. As a result, instead of the head of the family, who was responsible for allocating land to be cultivated, being able to borrow on behalf of the whole family, individual cultivators had to seek credit. Borrowing directly for production on their own account gave the cultivators a new, independent income. The impact of this change—whether good or bad—on the social structure of the area was not even considered by the analyst when the project was formulated (Olivares 1978).

ADMINISTRATIVE PROBLEMS. The experience of the projects reported in the 1981 review reinforced conclusions about administrative structures reached in earlier reviews. Among the projects in the 1981 review, the performance level was high in ten of the twenty-two completed projects in which special efforts had been made to strengthen administrative and technical capabilities; partial success was achieved in another six; and the results were negligible in four. In line with the experience of previous years, there was frequently a close association between institutional and project performance. On the one hand, the three worst performers included in the 1981 review—all with negative rates of return—shared a pattern of weak management that was not corrected as implementation proceeded. On the other hand, nine of the best-performing projects reviewed in 1981 were implemented by agencies that were noted for good administration or that made special efforts to improve their administrative effectiveness during the implementation period. In at least one instance, an effort to improve the effectiveness of implementation paid dividends by enabling the agency to overcome initial administrative and design difficulties.

Past project performance reviews have led to the conclusion that "specially created project implementation units [have] an isolated and precarious existence, usually [run] into difficulties, and should, as far as possible, be avoided as a temporary device to by-pass institutional weaknesses and to insulate . . . projects from the larger institutional environment" (World Bank 1981*a*, p. 27).

Staffing is a major problem in almost all development projects. Difficulties can be institutional—for example, restrictive governmental salary policies, civil service procedures, and promotion regulations—or can take the form of shortages of certain kinds of skilled people. One solution is often the use of consultants. Yet there frequently are difficulties between local project personnel and external consultants. Other common personnel problems include incompetent staff, ineffective training, high turnover, and poor matching of specific individuals with specific jobs.

Seven of the projects in the 1981 review made use of coordinating committees as an institutional instrument. As had been the case in earlier reviews, the experience was less than satisfactory. On the basis of this experience, the review concluded that "(1) high-level coordinating committees are generally not effective; (2) if formal coordination is needed, it should be established at the required technical or administrative level; and (3) a project unit within an existing organization may usefully undertake coordinating administrative functions" (World Bank 1981*a*, p. 28).

Delays in procurement will result in shortages of material, especially of foreign equipment. Sometimes delay is due to inadequate foresight and forward planning and sometimes (particularly in rural development projects) to unfamiliarity with procurement practices. The importance of timely procurement must be emphasized from the first stages of the project cycle and should be prominently included in the detailed implementation schedules.

Government administrative and managerial practices are at least as important to project implementation as the skills of project managers. If the central or local administrative processes are inadequate, the projects will encounter delays and, almost always, consequent cost increases. Common problems include slow and cumbersome decisionmaking, poor systems to authorize disbursement of project funds, ill-defined organizational arrangements, inadequate coordination among different agencies involved with a project, and, sometimes, government structures that deny appropriate authority to the project manager.

POLICY ENVIRONMENT. Every project must be implemented within a framework of policies set by the government. If these are such that farmers' incentives are destroyed or other serious impediments are put in the way of project implementation, then the project cannot be expected to achieve satisfactory results.

The overriding importance of producer prices in affecting producer income, production levels, and economic efficiency was confirmed in the 1981 review. Prices contributed to expansion of production by encouraging farmers to participate in the project, to expand areas devoted to the project crops, and to use more inputs and thereby increase yields. The 1981 review analyzed project performance in relation to prices in eighteen projects. Eleven out of thirteen projects implemented under favorable prices achieved or surpassed their production objectives; all five under unfavorable prices failed to do so. Projects implemented under favorable prices offered an average rate of return at reestimate of 22 percent, whereas those under unfavorable prices averaged 10 percent.

The issue of producer prices was developed in more detail in the 1980 review (World Bank 1980). Producer price information was available from twenty-seven projects. Of those in which producer prices were judged unfavorable, 33 percent reflected low world market prices about which the individual country could do little, 25 percent had producer prices much below world market levels because of government decisions about price policy, and in the remaining 42 percent there was no direct link between the producer prices and the world market.

Depressed world market prices for dairy produce affected one agricultural credit project in a North African country. Local milk production had to compete with reconstituted milk, which was imported at very low prices. This hampered the dairy farm component of the project because farmers were unwilling to invest in uncompetitive dairy enterprises. In a large irrigation project in Latin America, about 70 percent of the cropped project area was originally planted with cotton when the project began operation in 1967 because farmers were encouraged by very high prices and readily available credit. As international prices declined, the area planted in cotton dropped to 40,000 hectares in 1973 and climbed back to 62,000 hectares in 1978 when the prices recovered again, but the area remained substantially below the 100,000 hectares projected at appraisal.

Government policy to tax farmers producing groundnuts and cotton kept the producer prices much below world market levels in two projects in one East African country, and the area under these crops fell 40 to 50 percent short of appraisal estimates. Another example comes from a tobacco project in another country in the same region. Producer prices for tobacco in the country increased 26 percent during the 1972–78 period, while world market prices went up 75 percent and the price of maize, a competing crop, by 226 percent. Government policies to tax export crops and equalize average returns on labor for all crops caused the farmer's share in the selling price of processed tobacco to decline from 66 percent in 1965–66 to 37 percent in 1977–78. As a result, tobacco production stagnated, and the project itself became economically viable only because farmers switched to higher-valued maize production.

Other projects suffering from low producer prices not directly linked to world market prices included: a commercial farming project in a third East African country in which poor handling of tobacco resulted in low quality and low prices; a project with a vegetable component in West Africa in which the project authority limited tomato production by paying low prices to farmers; and a Central American livestock project in which the freezing of milk prices caused most of the specialized dairy farms around the capital city to close down permanently.

In contrast, profitable producer prices—prevalent in only about 30 percent of the projects included in the 1980 review—had strong positive effects. In one livestock project, for instance, milk production after four years was already 50 percent of the target for full development after eight years, mainly because of the government's pricing policy for milk relative to beef. A West African cotton project similarly benefited from higher-than-expected world cotton prices. Although production targets were not met, farm income objectives were achieved, and cotton export earnings and targets for economic return were exceeded.

Such experiences, repeated over and over, emphasize the importance of taking price policies into account as a factor when designing and implementing agricultural projects.

Problems of poor project analysis

When a project analysis has failed to anticipate the outcome of a project investment, a common reason appears to have been simply poor preparation of the analysis. A number of such cases were analyzed in a review prepared by Olivares (1978), from which this section draws heavily.

Underestimated costs were common, either as a result of the analyst's being systematically optimistic about cost or making an especially poor estimate about the cost of particular components. Sometimes a component necessary for proper functioning of the project or an activity critical to the project was omitted from the cost estimates, even though in the same analysis it was noted that it would be essential to proper execution

of the project. In the projects reviewed, components commonly omitted from the cost estimates (although not necessarily from the project and closely associated activities planned by the technicians) included agricultural extension to help farmers adopt new practices, training programs for project technicians, agronomic and livestock trials, complementary infrastructure such as roads or market facilities, and the expansion of the credit availability critical to the farmers' ability to adopt new techniques based on purchased inputs.

Excessively optimistic projections frequently were made during project preparation. In the projects reviewed, overestimates were common in projecting areas to be brought under cultivation, yields, rates of increase in livestock herds, and total production in the project area. The most common of these overestimates proved to be in cultivation intensity in irrigation projects and in the calving rate in cattle production projects. Project analyses frequently were too optimistic about the rate at which new cultivation practices would be adopted with irrigation, about the rate at which new areas would be brought under methods of improved cultivation, and about the rate at which the new technology could be applied under farm conditions.

When analyses of crop or livestock projects in rainfed areas did not predict the outcome well, the reason was often a failure to consider explicitly the variability of the climate and thus to overestimate returns. The analysis for one project undertaken in the Sahel region of Africa made no allowance for the variability of the climate, although the same analysis noted the likelihood of one or two dry years about once every five to seven years. The drought of 1973–75 paralyzed the project and forced planners to reevaluate and completely redesign the project. One livestock project in a Mediterranean country assumed that the weather during the project life would be "normal," despite the fact that in this region almost no year approaches this statistical computation. Nearly every particular year in the region is either too dry or too rainy, with the rains coming either too early or too late, and so forth. Naturally, making no allowance for this variability led to an overestimate of the project's yield and its attractiveness to the farmers involved.

Project evaluations commonly assumed too optimistic a calendar for project implementation. The analyses often did not test the effect on the project return of delays in getting the project under way—almost a normal situation in agricultural projects in general—or of delays in project execution at a later stage.

The return from investment in the agricultural projects examined was found to have been overestimated sometimes because the analysis failed to account for an adverse effect of the investment on production, either in the project area or elsewhere. In one project in Latin America, the main canals were lined to prevent water loss and to increase water delivery to the field. The analyst failed, however, to account for the irrigation of adjacent areas by wells recharged by seepage from the canals. The reduced output from these adjacent areas once the project was under way was not deducted from the benefits in the analysis. Of course, this led to an overestimate of the benefit from the irrigation project. Several irriga-

tion projects in Asia were found to have reduced the spawning grounds of commercially important fish. The result was that much of the benefit from expanded irrigation was offset by a fall in fish production and reduced income for thousands of fishermen.

Project analysts often made errors when translating technical assumptions into projections of project performance. In one project it was assumed that 80 percent of the projected increase in area to be cultivated using more intensive technology would be reached in the first year, with the remaining 20 percent realized over the succeeding four years. In another project, expansion of the irrigated area was assumed to take place before the basic irrigation construction was to have been completed. In yet another case, the analyst assumed that fruit trees would reach full production the year they were planted. Such obvious errors could have been avoided just by cross-checking with the technical specialists as the analysis proceeded.

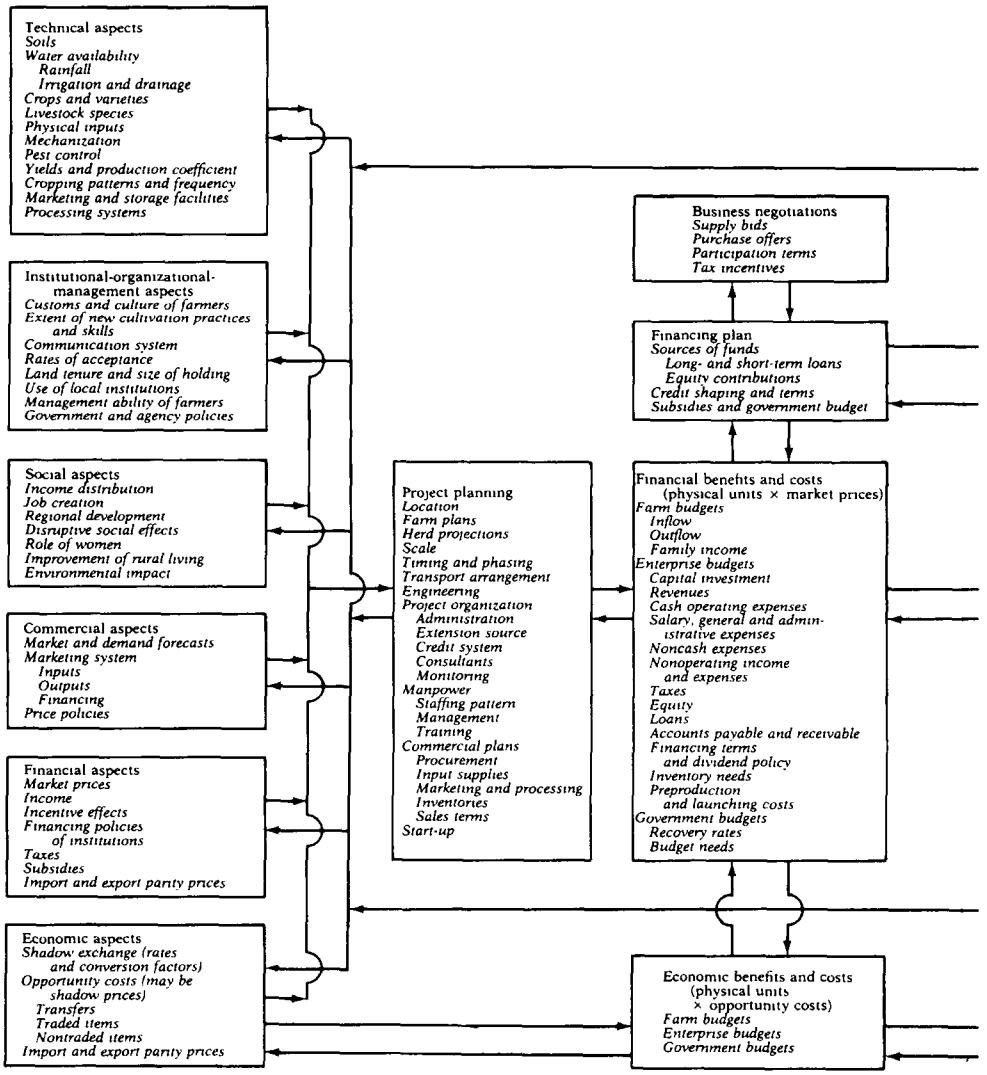
Steps in Project Analysis

Preparing a project analysis is anything but a neat, continuous process with well-defined steps, each of which is completed before the next and never retraced. Instead, the whole process is iterative; that is, the analyst must continuously go back and adjust earlier decisions in the light of what is learned from later analysis. In general, the process begins with an idea about the broad nature and objectives of a proposed project that has been supplied by the political or planning process. We will know, for example, that we are expected to prepare an irrigation project in a particular area, or a marketing project to reduce seasonal fluctuations in the price of an agricultural product, or an extension of an existing land settlement project. The next step is to examine carefully the pertinent technical relations on which to base the technical planning. We then begin to price these technical requirements and to develop some projections of inputs and outputs as the basis for the financial analysis. These financial prices are then adjusted to give economic values on which to base the economic analysis and to judge the project's contribution to the national income. At each step we must consider the institutional, organizational, and managerial aspects and the social effects. And, of course, at each step we may want to go back and revise earlier parts of the plan. The flow chart in figure 1-1 depicts this process schematically.

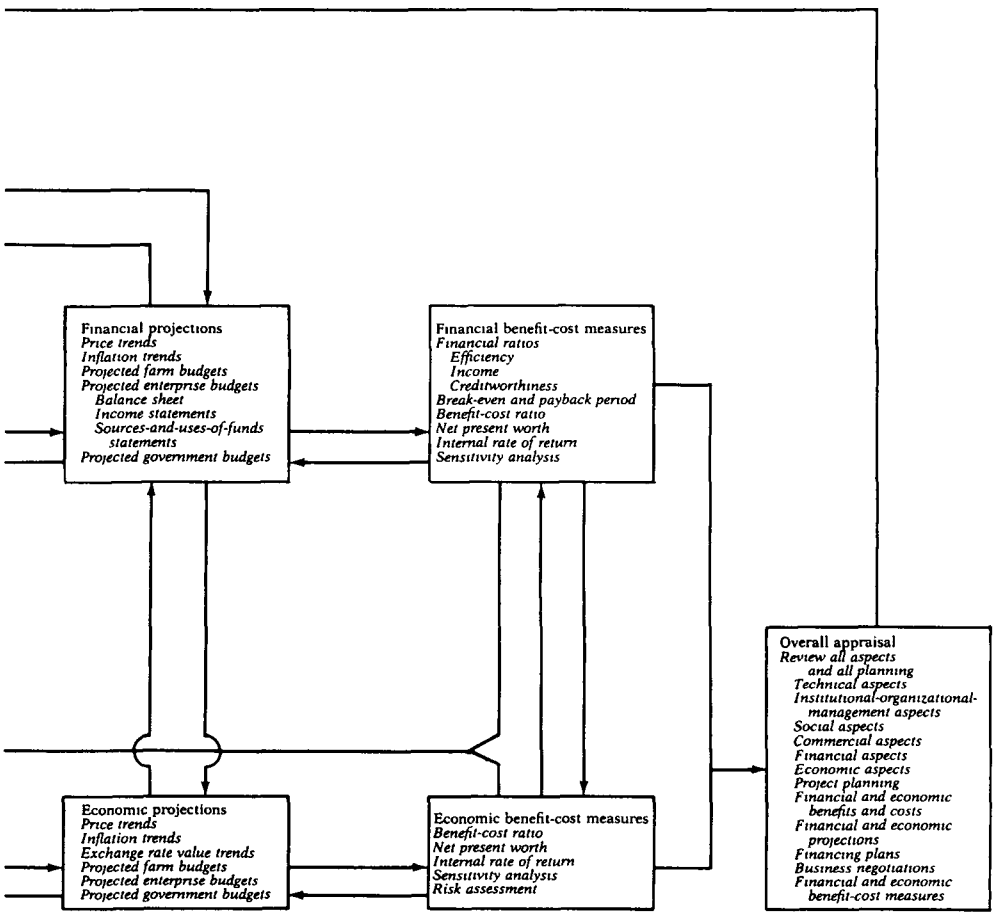
The sequence of topics in this book generally follows the order of the analytical process in preparing a financial, and then an economic, analysis of an agricultural project. We will not consider in detail the technical, institutional-organizational-managerial, social, or commercial aspects of preparing a project. Instead, we will assume that such preparations are already well in hand and that specialists knowledgeable in these matters can be easily consulted in the course of the analytical process.

We will turn first to what constitute costs and benefits in agricultural projects (chapter 2). Then we will proceed to how one can find market prices on which to base the project analysis (chapter 3). From these topics

Figure 1-1. *Formulation and Analysis of Agricultural Projects*



Source: Adapted from Frank L. Lamson-Scribner and Robert B. Youker, "The Project Cycle and the Project Appraisal Process," training material of the Economic Development Institute (EDI), CN-419 (Washington, D C · World Bank, 1975), exhibit 5.


Financial projections
Price trends
Inflation trends
Projected farm budgets
Projected enterprise budgets
Balance sheet
Income statements
Sources-and-uses-of-funds statements
Projected government budgets
Financial benefit-cost measures
Financial ratios
Efficiency
Income
Creditworthiness
Break-even and payback period
Benefit-cost ratio
Net present worth
Internal rate of return
Sensitivity analysis
Overall appraisal
Review all aspects and all planning
Technical aspects
Institutional-organizational-management aspects
Social aspects
Commercial aspects
Financial aspects
Economic aspects
Project planning
Financial and economic benefits and costs
Financial and economic projections
Financing plans
Business negotiations
Financial and economic benefit-cost measures
Economic projections
Price trends
Inflation trends
Exchange rate value trends
Projected farm budgets
Projected enterprise budgets
Projected government budgets
Economic benefit-cost measures
Benefit-cost ratio
Net present worth
Internal rate of return
Sensitivity analysis
Risk assessment

we will move on to discuss how these market prices can be transformed into accounts, which become the basis for the financial analysis, first by laying out and projecting model farm budgets (chapter 4). These projected farm budgets form the basis of an idea about how much a farm family participating in a project will have to live on as the project proceeds. This amount with the project, compared with what would be the amount without the project, yields an estimate about the incremental income that will accrue to the farm family. On the basis of this estimate, a judgment can be formed about the incentive effect of a proposed project on farmers who might participate. One can also estimate the rate of return to the farmer's own capital investment and to all capital invested on the farm.

By preparing and projecting budgets for agricultural processing industries such as sugar mills or cotton gins that may be included in a project (chapter 5), one can make similar judgments about the incremental net benefit arising from investment in these firms, whether they are in the public or the private sector, and about the incentives for participation by the private sector if this is to be the vehicle for investment. A separate set of accounts for government agencies (chapter 6) will permit an estimate of the effect of the project on government revenue.

With these budgets in hand, the various market prices used in each are adjusted, if need be, to reflect economic values from the standpoint of the society as a whole (chapter 7). These economic values are then totaled or "aggregated," as it is more often termed (chapter 8). This is done for the incremental farm production from the project (either by aggregating according to model types for the total number of farms in the project or by aggregating the total area devoted to the various crops in the project), for all the revenue-earning entities, and for the various government agencies. The aggregation gives the total incremental net benefit the society will realize from the project. From this and from earlier budgets, we can estimate the return that individuals and the society will realize from their investment in the project (chapters 9 and 10). Of course, at each stage in this sequence we will want to review our earlier work and revise it in light of later analysis.

The book concludes with a set of generalized guidelines for preparing reports of agricultural and rural development project analyses (appendix A), two discounting tables (appendix B), and a brief discussion about institutional sources of assistance for the preparation of agricultural projects (appendix C). An annotated bibliography and a glossary-index are included as references for the reader.

2

Identifying Project Costs and Benefits

WE UNDERTAKE ECONOMIC ANALYSES of agricultural projects to compare costs with benefits and determine which among alternative projects have an acceptable return. The costs and benefits of a proposed project therefore must be identified. Furthermore, once costs and benefits are known, they must be priced, and their economic values determined. All of this is obvious enough, but frequently it is tricky business.

What costs and benefits in agricultural projects are, and how we can define them in a consistent manner, are the topics of this chapter. In chapter 3 we will examine how we can obtain market prices. After the financial analyses are discussed in chapters 4–6, the economic analysis is addressed in chapter 7 with a discussion of how to adjust market prices to reflect the real resource flows.

Objectives, Costs, and Benefits

In project analysis, the objectives of the analysis provide the standard against which costs and benefits are defined. Simply put, a cost is anything that reduces an objective, and a benefit is anything that contributes to an objective.

Facing page: Harvesting rice in the Alto Turi region, northeast Brazil.

The problem with such simplicity, however, is that each participant in a project has many objectives. For a farmer, a major objective of participating is to maximize the amount his family has to live on. But this is only one of the farmer's interests. He may also want his children to be educated; as a result, they may not be available to work full time in the fields. He may also value his time away from the fields: a farmer will not adopt a cropping pattern, however remunerative, that requires him to work ten hours a day 365 days a year. Taste preference may lead a farmer to continue to grow a traditional variety of rice for home consumption even though a new, high-yielding variety might increase his family income more. A farmer may wish to avoid risk, and so may plan his cropping pattern to limit the risk of crop failure to an acceptable level or to reduce the risk of his depending solely on the market for the food grains his family will consume. As a result, although he may be able to increase his income over time if he grows cotton instead of wheat or maize, he would rather continue growing food grains to forestall the possibility that in any one year the cotton crop might fail or that food grains might be available for purchase in the market only at a very high price. All these considerations affect a farmer's choice of cropping pattern and thus the income-generating capacity of the project. Yet all are sensible decisions in the farmer's view. In the analytical system presented here, we will try to identify the cropping pattern that we think the farmer will most probably select, and then we will judge the effects of that pattern on his incremental income and, thus, on the new income generated by the project.

For private business firms or government corporations, a major objective is to maximize net income, yet both have significant objectives other than simply making the highest profit possible. Both will want to diversify their activities to reduce risk. The private store owner may have a preference for leisure, which leads him to hire a manager to help operate his store, especially during late hours. This reduces the income—since the manager must be paid a salary—but it is a sensible choice. For policy reasons, a public bus corporation may decide to maintain services even in less densely populated areas or at off-peak hours and thereby reduce its net income. In the analytical system here, we first identify the operating pattern that the firms in the project will most likely follow and then build the accounts to assess the effects of that pattern on the income-generating capacity of the project.

A society as a whole will have as a major objective increased national income, but it clearly will have many significant, additional objectives. One of the most important of these is income distribution. Another is simply to increase the number of productive job opportunities so that unemployment may be reduced—which may be different from the objective of income distribution itself. Yet another objective may be to increase the proportion of savings in any given period so there will be more to invest, faster growth, and, hence, more income in the future. Or, there may be issues to address broader than narrow economic considerations—such as the desire to increase regional integration, to upgrade the

general level of education, to improve rural health, or to safeguard national security. Any of these objectives might lead to the choice of a project (or a form of a project) that is not the alternative that would contribute most to national income narrowly defined.

No formal analytical system for project analysis could possibly take into account all the various objectives of every participant in a project. Some selection will have to be made. In the analytical system here, we will take as formal criteria very straightforward objectives of income maximization and accommodate other objectives at other points in the process of project selection. The justification for this is that in most developing countries increased income is probably the single most important objective of individual economic effort, and increased national income is probably the most important objective of national economic policy.

For farms, we will take as the objective maximizing the incremental net benefit—the increased amount the farm family has to live on as a result of participating in the project—derived as outlined in chapter 4. For a private business firm or corporation in the public sector, we will take as the objective maximizing the incremental net income, to which we will return in chapter 5. And for the economic analysis conducted from the standpoint of the society as a whole, we will take as the objective maximizing the contribution the project makes to the national income—the value of all final goods and services produced during a particular period, generally a year. This is virtually the same objective, except for minor formal variations in definition, as maximizing gross domestic product (GDP). It is important to emphasize that taking the income a project will contribute to a society as the formal analytical criterion in economic analysis does not downgrade other objectives or preclude our considering them. Rather, we will simply treat consideration of other objectives as separate decisions. Using our analytical system, we can judge which among alternative projects or alternative forms of a particular project will make an acceptable contribution to national income. This will enable us to recommend to those who must make the investment decision a project that has a high income-generating potential and also will make a significant contribution to other social objectives. For example, from among those projects that make generally the same contribution to increased income, we can choose the one that has the most favorable effects on income distribution, or the one that creates the most jobs, or the one that is the most attractive among those in a disadvantaged region.

Thus, in the system of economic analysis discussed here, anything that reduces national income is a cost and anything that increases national income is a benefit. Since our objective is to increase the sum of all final goods and services, anything that directly reduces the total final goods and services is obviously a cost, and anything that directly increases them is clearly a benefit. But recall, also, the intricate workings of the economic system. When the project analyzed uses some intermediate good or service—something that is used to produce something else—by a

chain of events it eventually reduces the total final goods and services available elsewhere in the economy. On the one hand, if we divert an orange that can be used for direct consumption—and thus is a final good—to the production of orange juice, also a final good, we are reducing the total available final goods and services, or national income, by the value of the orange and increasing it by the value of the orange juice. On the other hand, if we use cement to line an irrigation canal, we are not directly reducing the final goods and services available; instead, we are simply reducing the availability of an intermediate good. But the consequence of using the cement in the irrigation project is to shift the cement away from some other use in the economy. This, in turn, reduces production of some other good, and so on through the chain of events until, finally, the production of final goods and services, the national income, is reduced. Thus, using cement in the project is a cost to the economy. How much the national income will be reduced by using the cement for the project is part of what we must estimate when we turn, in chapter 7, to deriving economic values. On the benefit side, we have a similar pattern. Lining a canal increases available water that, in turn, may increase wheat production, and so on through a chain of events until in the end the total amount of bread is increased. By this mechanism, the project leads to an increase in the total amount of final goods and services, which is to say it increases the national income. Again, part of the analyst's task in the economic analysis is to estimate the amount of this increase in national income available to the society; that is, to determine whether, and by how much, the benefits exceed the costs in terms of national income.

If this rather simple definition of economic costs and benefits is kept in mind, possible confusion will be avoided when shadow prices are used to value resource flows, a matter taken up in chapter 7.

Note that, by defining our objective for economic analysis in terms of change in national income, we are defining it in real terms. (Real terms, as opposed to money terms, refer to the physical, tangible characteristics of goods and services.) To an important degree, economic analysis, in contrast to financial analysis, consists in tracing the real resource flows induced by an investment rather than the investment's monetary effects.

With these objectives defined, we may then say that in financial analysis our numeraire—the common measurement used as the unit of account—is a unit of currency, generally domestic currency, whereas in economic analysis our numeraire is a unit of national income, generally also expressed in domestic currency. We will return to this topic in our discussion of determining economic values in chapter 7.

In the economic analysis we will assume that all financing for a project comes from domestic sources and that all returns from the project go to domestic residents. [This is one reason why we identify our social objective with the gross *domestic* product (GDP) instead of the more familiar gross *national* product (GNP).] This convention—almost universally accepted by project analysts—separates the decision of how good a project is in its income-generating potential from the decision of how to

finance it. The actual terms of financing available for a particular project will not influence the evaluation. Instead, we will assume that the proposed project is the best investment possible and that financing will then be sought for it at the best terms obtainable. This convention serves well whenever financing can be used for a range of projects or even versions of roughly the same project. The only case in which it does not hold well is the rather extreme case in which foreign financing is very narrowly tied to a particular project and will be lost if the project is not implemented. Then the analyst may be faced with the decision of implementing a lower-yielding project with foreign financing or choosing a higher-yielding alternative but losing the foreign loan.

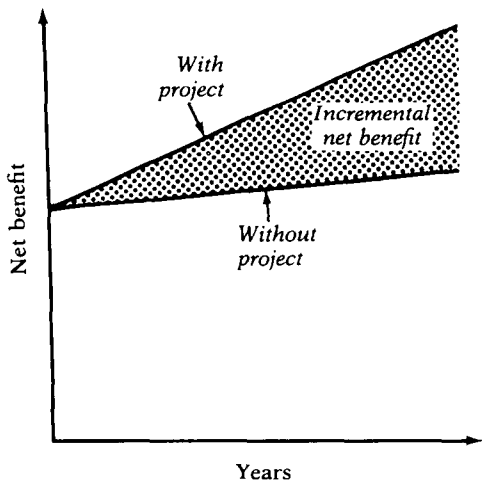
"With" and "Without" Comparisons

Project analysis tries to identify and value the costs and benefits that will arise *with* the proposed project and to compare them with the situation as it would be *without* the project. The difference is the incremental net benefit arising from the project investment. This approach is not the same as comparing the situation "before" and "after" the project. The before-and-after comparison fails to account for changes in production that would occur without the project and thus leads to an erroneous statement of the benefit attributable to the project investment.

A change in output without the project can take place in two kinds of situations. The most common is when production in the area is already growing, if only slowly, and will probably continue to grow during the life of the project. The objective of the project is to increase growth by intensifying production. In Syria at the time the First Livestock Development Project was appraised, for example, production in the national sheep flock was projected to grow at about 1 percent a year without the project. The project was to increase and stabilize sheep production and the incomes of seminomadic flock owners and sheep fatteners by stabilizing the availability of feed and improving veterinary services. With the project, national flock production was projected to grow at the rate of 3 percent a year. In this case, if the project analyst had simply compared the output before and after the project, he would have erroneously attributed the total increase in sheep production to the project investment. Actually, what can be attributed to the project investment is only the 2 percent incremental increase in production in excess of the 1 percent that would have occurred anyway (see figure 2-1).

A change in output can also occur without the project if production would actually fall in the absence of new investment. In Guyana, on the north coast of South America, rice and sugarcane are produced on a strip of clay and silt soil edging the sea. The coast was subject to erosion from wave action. Under the Sea Defense Project, the government of Guyana has built seawalls to prevent the erosion. The benefit from this project, then, is not increased production but avoiding the loss of agricultural

Figure 2-1. *National Sheep Flock, First Livestock Development Project, Syria*



output and sites for housing. A simple before-and-after comparison would fail to identify this benefit (figure 2-2).

In some cases, an investment to avoid a loss might also lead to an increase in production, so that the total benefit would arise partly from the loss avoided and partly from increased production. In Pakistan, many areas are subject to progressive salinization as a result of heavy irrigation and the waterlogging that is in part attributable to seepage from irrigation canals. Capillary action brings the water to the surface where evaporation occurs, leaving the salt on the soil. If nothing is done to halt the process, crop production will fall. A project is proposed to line some of the canals, thus to reduce the seepage and permit better drainage

Figure 2-2. *Sea Defense Project, Guyana*

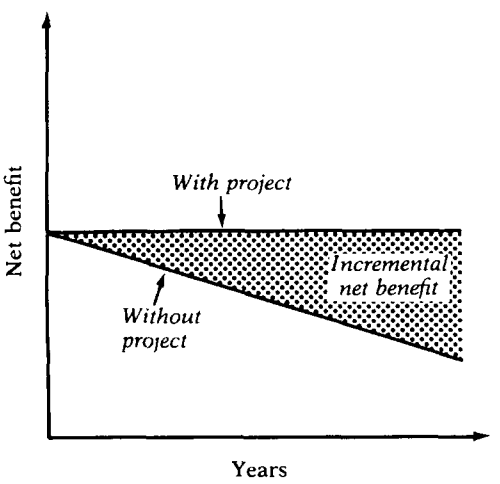
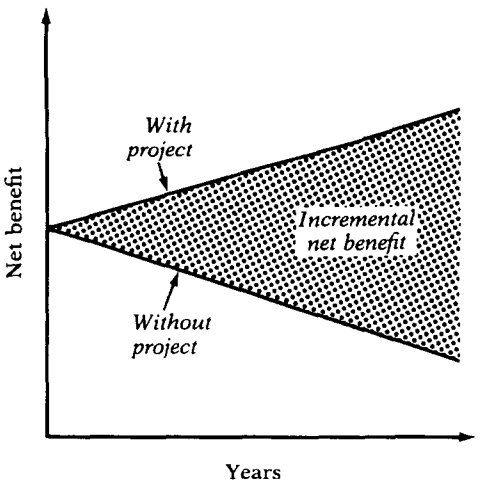


Figure 2-3. *Canal-lining Project, Pakistan*

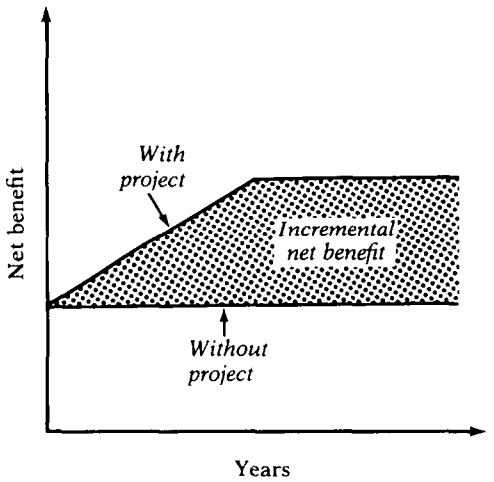


between irrigations. The proposed project is expected to arrest salinization, to save for profitable use the irrigation water otherwise lost to seepage, and to help farmers increase their use of modern inputs. The combination of measures would not only avoid a loss but also lead to an increase in production. Again, a simple before-and-after comparison would fail to identify the benefit realized by avoiding the loss (figure 2-3).

Of course, if no change in output is expected in the project area without the project, then the distinction between the before-and-after comparison and the with-and-without comparison is less crucial. In some projects the prospects for increasing production without new investment are minimal. In the Kemubu Irrigation Project in northeastern Malaysia, a pump irrigation scheme was built that permitted farmers to produce a second rice crop during the dry season. Without the project, most of the area was used for grazing, and with the help of residual moisture or small pumps some was used to produce tobacco and other cash crops. Production was not likely to increase because of the limited amount of water available. With the project now in operation, rice is grown in the dry season. Of course, the value of the second rice crop could not be taken as the total benefit from the project. From this value must be deducted the value forgone from the grazing and the production of cash crops. Only the incremental value could be attributed to the new investment in pumps and canals (figure 2-4).

Another instance where there may be no change in output without the project is the obvious one found in some settlement projects. Without the project there may be no economic use of the area at all. In the Alto Turi Land Settlement Project in northeastern Brazil, settlers established their holdings by clearing the forest, planting upland rice, and then establishing pasture for production of beef cattle. At the time the settlers took up their holdings the forest had not been economically exploited—nor was it likely to be, at least for many years, in the absence of the project. In

Figure 2-4. *Kemubu Irrigation Project, Malaysia*

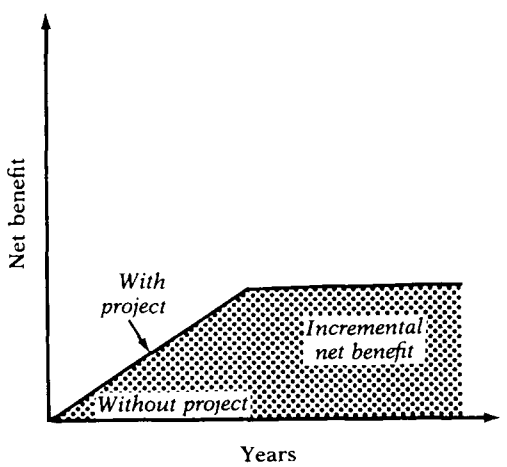


this case, the output without the project would be the same as the output before the project (figure 2-5).

Direct Transfer Payments

Some entries in financial accounts really represent shifts in claims to goods and services from one entity in the society to another and do not reflect changes in national income. These are the so-called direct transfer payments, which are much easier to identify if our definition of costs and benefits is kept in mind. In agricultural project analysis four kinds of direct transfer payments are common: taxes, subsidies, loans, and debt service (the payment of interest and repayment of principal).

Figure 2-5. *Alto Turi Land Settlement Project, Brazil*



Take taxes, for example. In financial analysis a tax payment is clearly a cost. When a farmer pays a tax, his net benefit is reduced. But the farmer's payment of tax does not reduce the national income. Rather, it transfers income from the farmer to the government so that this income can be used for social purposes presumed to be more important to the society than the increased individual consumption (or investment) had the farmer retained the amount of the tax. Because payment of tax does not reduce national income, it is not a cost from the standpoint of the society as a whole. Thus, in economic analysis we would not treat the payment of taxes as a cost in project accounts. Taxes remain a part of the overall benefit stream of the project that contributes to the increase in national income.

Of course, no matter what form a tax takes, it is still a transfer payment—whether a direct tax on income or an indirect tax such as a sales tax, an excise tax, or a tariff or duty on an imported input for production. But some caution is advisable here. Taxes that are treated as a direct transfer payment are those representing a diversion of net benefit to the society. Quite often, however, government charges for goods supplied or services rendered may be called taxes. Water rates, for example, may be considered a tax by the farmer, but from the standpoint of the society as a whole they are a payment by the farmer to the irrigation authority in exchange for water supplied. Since building the irrigation system reduces national income, the farmer's payment for the water is part of the cost of producing the crop, the same as any other payment for a production input. Other payments called taxes may also be payments for goods and services rendered rather than transfers to the government. A stevedoring charge at the port is not a tax but a payment for services and so would not be treated as a duty would be. Whether a tax should be treated as a transfer payment or as a payment for goods and services depends on whether the payment is a compensation for goods and services needed to carry out the project or merely a transfer, to be used for general social purposes, of some part of the benefit from the project to the society as a whole.

Subsidies are simply direct transfer payments that flow in the opposite direction from taxes. If a farmer is able to purchase fertilizer at a subsidized price, that will reduce his costs and thereby increase his net benefit, but the cost of the fertilizer in the use of the society's real resources remains the same. The resources needed to produce the fertilizer (or import it from abroad) reduce the national income available to the society. Hence, for economic analysis of a project we must enter the full cost of the fertilizer.

Again, it makes no difference what form the subsidy takes. One form is that which lowers the selling price of inputs below what otherwise would be their market price. But a subsidy can also operate to increase the amount the farmer receives for what he sells in the market, as in the case of a direct subsidy paid by the government that is added to what the farmer receives in the market. A more common means to achieve the same result does not involve direct subsidy. The market price may be

maintained at a level higher than it otherwise would be by, say, levying an import duty on competing imports or forbidding competing imports altogether. Although it is not a direct subsidy, the difference between the higher controlled price set by such measures and the lower price for competing imports that would prevail without such measures does represent an indirect transfer from the consumer to the farmer.

Credit transactions are the other major form of direct transfer payment in agricultural projects. From the standpoint of the farmer, receipt of a loan increases the production resources he has available; payment of interest and repayment of principal reduce them. But from the standpoint of the economy, things look different. Does the loan reduce the national income available? No, it merely *transfers* the control over resources from the lender to the borrower. Perhaps one farmer makes the loan to his neighbor. The lending farmer cannot use the money he lends to buy fertilizer, but the borrowing farmer can. The use of the fertilizer, of course, is a cost to the society because it uses up resources and thus reduces the national income. But the loan transaction does not itself reduce the national income; it is, rather, a direct transfer payment. In reverse, the same thing happens when the farmer repays his loan. The farmer who borrowed cannot buy fertilizer with the money he uses to repay the loan his neighbor made, but his neighbor can. Thus, the repayment is also a direct transfer payment.

Some people find the concept of transfer payments easier to understand if it is stated in terms of real resource flows. Taking this approach in economic analysis, we see that a tax does not represent a real resource flow; it represents only the transfer of a claim to real resource flows. The same holds true for a direct subsidy that represents the transfer of a claim to real resources from, say, an urban consumer to a farmer. This line of reasoning also applies to credit transactions. A loan represents the transfer of a claim to real resources from the lender to the borrower. When the borrower pays interest or repays the principal, he is transferring the claim to the real resources back to the lender—but neither the loan nor the repayment represents, in itself, *use* of the resources.

Costs of Agricultural Projects

In almost all project analyses, costs are easier to identify (and value) than benefits. In every instance of examining costs, we will be asking ourselves if the item reduces the net benefit of a farm or the net income of a firm (our objectives in financial analysis), or the national income (our objective in economic analysis).

Physical goods

Rarely will physical goods used in an agricultural project be difficult to identify. For such goods as concrete for irrigation canals, fertilizer and pesticides for increasing production, or materials for the construction of

homes in land settlement projects, it is not the identification that is difficult but the technical problems in planning and design associated with finding out how much will be needed and when.

Labor

Neither will the labor component of agricultural projects be difficult to identify. From the highly skilled project manager to the farmer maintaining his orchard while it is coming into production, the labor inputs raise less a question of what than of how much and when. Labor may, however, raise special valuation problems that call for the use of a shadow price. Confusion may also arise on occasion in valuing family labor. Valuing family labor will be discussed with farm budgets in chapter 4, and the overall question of valuing unskilled labor will be taken up in chapter 7.

Land

By the same reasoning, the land to be used for an agricultural project will not be difficult to identify. It generally is not difficult to determine where the land necessary for the project will be located and how much will be used. Yet problems may arise in valuing land because of the very special kind of market conditions that exist when land is transferred from one owner to another. These valuation problems will also be considered with farm budgets in chapter 4 and with determining economic values in chapter 7.

Contingency allowances

In projects that involve a significant initial investment in civil works, the construction costs are generally estimated on the initial assumption that there will be no modifications in design that would necessitate changes in the physical work; no exceptional conditions such as unanticipated geological formations; and no adverse phenomena such as floods, landslides, or unusually bad weather. In general, project cost estimates also assume that there will be no relative changes in domestic or international prices and no inflation during the investment period. It would clearly be unrealistic to rest project cost estimates only on these assumptions of perfect knowledge and complete price stability. Sound project planning requires that provision be made in advance for possible adverse changes in physical conditions or prices that would add to the baseline costs. Contingency allowances are thus included as a regular part of the project cost estimates.

Contingency allowances may be divided into those that provide for physical contingencies and those for price contingencies. In turn, price contingency allowances comprise two categories, those for relative changes in price and those for general inflation. Physical contingencies and price contingencies that provide for increases in relative costs under-

lie our expectation that physical changes and relative price changes are likely to occur, even though we cannot forecast with confidence just how their influence will be felt. The increase in the use of real goods and services represented by the physical contingency allowance is a real cost and will reduce the final goods and services available for other purposes; that is, it will reduce the national income and, hence, is a cost to the society. Similarly, a rise in the relative cost of an item implies that its productivity elsewhere in the society has increased; that is, its potential contribution to national income has risen. A greater value is forgone by using the item for our project; hence, there is a larger reduction in national income. Physical contingency allowances and price contingency allowances for relative changes in price, then, are expected—if unallocated—project costs, and they properly form part of the cost base when measures of project worth are calculated.

General inflation, however, poses a different problem. As we will note in chapter 3 in discussing future prices, in project analysis the most common means of dealing with inflation is to work in constant prices, on the assumption that all prices will be affected equally by any rise in the general price level. This permits valid comparisons among alternative projects. If inflation is expected to be significant, however, provision for its effects on project costs needs to be made in the project financing plan so that an adequate budget is obtained. Contingency allowances for inflation would not, however, be included among the costs in project accounts other than the financing plan.

Taxes

Recall that the payment of taxes, including duties and tariffs, is customarily treated as a cost in financial analysis but as a transfer payment in economic analysis (since such payment does not reduce the national income). The amount that would be deducted for taxes in the financial accounts remains in the economic accounts as part of the incremental net benefit and, thus, part of the new income generated by the project.

Debt service

The same approach applies to debt service—the payment of interest and the repayment of capital. Both are treated as an outflow in financial analysis. In economic analysis, however, they are considered transfer payments and are omitted from the economic accounts.

Treatment of interest during construction can give rise to confusion. Lending institutions sometimes add the value of interest during construction to the principal of the loan and do not require any interest payment until the project begins to operate and its revenues are flowing. This process is known as "capitalizing" interest. The amount added to the principal as a result of capitalizing interest during construction is

similar to an additional loan. Capitalizing interest defers interest cost, but when the interest payments are actually due, they will, of course, be larger because the amount of the loan has been increased. From the standpoint of economic analysis, the treatment of interest during construction is clear. It is a direct transfer payment the same as any other interest payment, and it should be omitted from the economic accounts. Often interest during construction is simply added to the capital cost of the project. To obtain the economic value of the capital cost, the amount of the interest during construction must be subtracted from the capital cost and omitted from the economic account.

In economic analysis, debt service is treated as a transfer within the economy even if the project will actually be financed by a foreign loan and debt service will be paid abroad. This is because of the convention of assuming that all financing for a project will come from domestic sources and all returns from the project will go to domestic residents. This convention, as noted earlier, separates the decision of how good a project is from the decision of how to finance it. Hence, even if it were expected that a project would be financed, say, by a World Bank loan, the debt service on that loan would not appear as a cost in the economic accounts of the project analysis.

Sunk costs

Sunk costs are those costs incurred in the past upon which a proposed new investment will be based. Such costs cannot be avoided, however poorly advised they may have been. When we analyze a proposed investment, we consider only future returns to future costs; expenditures in the past, or sunk costs, do not appear in our accounts.

In practice, if a considerable amount has already been spent on a project, the future returns to the future costs of completing the project would probably be quite attractive even if it is clear in retrospect that the project should never have been begun. The ridiculous extreme is when only one dollar is needed to complete a project, even a rather poor one, and when no benefit can be realized until the project is completed. The "return" to that last dollar may well be extremely high, and it would be clearly worthwhile to spend it. But the argument that because much has already been spent on a project it therefore must be continued is not a valid criterion for decision. There are cases in which it would be preferable simply to stop a project midway or to draw it to an early conclusion so that future resources might be freed for higher-yielding alternatives.

For evaluating past investment decisions, it is often desirable to do an economic and financial analysis of a completed project. Here, of course, the analyst would compare the return from all expenditures over the past life of the project with all returns. But this kind of analysis is useful only for determining the yield of past projects in the hope that judgments about future projects may be better informed. It does not help us decide what to do in the present. Money spent in the past is already gone; we do not have as one of our alternatives not to implement a completed project.

Tangible Benefits of Agricultural Projects

Tangible benefits of agricultural projects can arise either from an increased value of production or from reduced costs. The specific forms in which tangible benefits appear, however, are not always obvious, and valuing them may be quite difficult.

Increased production

Increased physical production is the most common benefit of agricultural projects. An irrigation project permits better water control so that farmers can obtain higher yields. Young trees are planted on cleared jungle land to increase the area devoted to growing oil palm. A credit project makes resources available for farmers to increase both their operating expenditures for current production—for fertilizers, seeds, or pesticides—and their investment—for a tubewell or a power thresher. The benefit is the increased production from the farm.

In a large proportion of agricultural projects the increased production will be marketed through commercial channels. In that case identifying the benefit and finding a market price will probably not prove too difficult, although there may be a problem in determining the correct value to use in the economic analysis.

In many agricultural projects, however, the benefits may well include increased production consumed by the farm family itself. Such is the case in irrigation rehabilitation projects along the north coast of Java. The home-consumed production from the projects increased the farm families' net benefit and the national income just as much as if it had been sold in the market. Indeed, we could think of the hypothetical case of a farmer selling his output and then buying it back. Since home-consumed production contributes to project objectives in the same way as marketed production, it is clearly part of the project benefits in both financial and economic analysis. Omitting home-consumed production will tend to make projects that produce commercial crops seem relatively high-yielding, and it could lead to a poor choice among alternative projects. Failure to include home-consumed production will also mean underestimating the return to agricultural investments relative to investments in other sectors of the economy.

When home-consumed crops will figure prominently in a project, the importance of careful financial analysis is increased. In this case, it is necessary to estimate not only the incremental net benefit—including the value of home-consumed production and money from off-farm sales—but also the cash available to the farmer. From the analysis of cash income and costs, one can determine if farmers will have the cash in hand to purchase modern inputs or to pay their credit obligations. It is possible to have a project in which home-consumed output increases enough for the return to the economy as a whole to be quite attractive, but in which

so little of the increased production is sold that farmers will not have the cash to repay their loans.

Quality improvement

In some instances, the benefit from an agricultural project may take the form of an improvement in the quality of the product. For example, the analysis for the Livestock Development Project in Ecuador, which was to extend loans to producers of beef cattle, assumed that ranchers would be able not only to increase their cattle production but also to improve the quality of their animals so that the average live price of steers per kilogram would rise from S/5.20 to S/6.40 in constant value terms over the twelve-year development period. (The symbol for Ecuadorian sucres is S/.) Loans to small dairy farmers in the Rajasthan Smallholder Dairy Improvement Project in India are intended to enable farmers not only to increase output but also to improve the quality of their product. Instead of selling their milk to make ghee (cooking oil from clarified butter), farmers will be able to sell it for a higher price in the Jaipur fluid milk market. As in these examples, both increased production and quality improvement are most often expected in agricultural projects, although both may not always be expected. One word of warning: both the rate and the extent of the benefit from quality improvement can easily be overestimated.

Change in time of sale

In some agricultural projects, benefits will arise from improved marketing facilities that allow the product to be sold at a time when prices are more favorable. A grain storage project may make it possible to hold grain from the harvest period, when the price is at its seasonal low, until later in the year when the price has risen. The benefit of the storage investment arises out of this change in "temporal value."

Change in location of sale

Other projects may include investment in trucks and other transport equipment to carry products from the local area where prices are low to distant markets where prices are higher. For example, the Fruit and Vegetable Export Project in Turkey included provision for trucks and ferries to transport fresh produce from southeastern Turkey to outlets in the European Common Market. The benefits of such projects arise from the change in "locational value."

In most cases the increased value arising from marketing projects will be split between farmers and marketing firms as the forces of supply and demand increase the price at which the farmer can sell in the harvest season and reduce the monopolistic power of the marketing firm or agency. Many projects are structured to ensure that farmers receive a larger part of the benefit by making it possible for them to build storage

facilities on their farms or to band together into cooperatives, but an agricultural project could also involve a private marketing firm or a government agency, in which case much of the benefit could accrue to someone other than farmers.

Changes in product form (grading and processing)

Projects involving agricultural processing industries expect benefits to arise from a change in the form of the agricultural product. Farmers sell paddy rice to millers who, in turn, sell polished rice. The benefit to the millers arises from the change in form. Canners preserve fruit, changing its form and making it possible at a lower cost to change its time or location of sale. Even a simple processing facility such as a grading shed gives rise to a benefit through changing the form of the product from run-of-the-orchard to sorted fruit. In the Himachal Pradesh Apple Marketing Project in northern India, the value of the apples farmers produce is increased by sorting; the best fruit is sold for fresh consumption while fruit of poorer quality is used to make a soft drink concentrate. In the process, the total value of the apples is increased.

Cost reduction through mechanization

The classic example of a benefit arising from cost reduction in agricultural projects is that gained by investment in agricultural machinery to reduce labor costs. Examples are tubewells substituting for hand-drawn or animal-drawn water, pedal threshers replacing hand threshing, or (that favorite example) tractors replacing draft animals. Total production may not increase, but a benefit arises because the costs have been trimmed (provided, of course, that the gain is not offset by displaced labor that cannot be productively employed elsewhere).

Reduced transport costs

Cost reduction is a common source of benefit wherever transport is a factor. Better feeder roads or highways may reduce the cost of moving produce from the farm to the consumer. The benefit realized may be distributed among farmers, truckers, and consumers.

Losses avoided

In discussing with-and-without comparisons in project analyses earlier in this chapter, we noted that in some projects the benefit may arise not from increased production but from a loss avoided. This kind of benefit stream is not always obvious, but it is one that the with-and-without test tends to point out clearly. In Jamaica, lethal yellowing is attacking the Jamaica Tall variety of coconut. The government has undertaken a large investment to enable farmers to plant Malayan Dwarf

coconuts, which are resistant to the disease. Total production will change very little as a result of the investment, yet both the farmers and the economy will realize a real benefit because the new investment prevents loss of income. The Lower Egypt Drainage Project involves the largest single tile drainage system in the world. The benefit will arise not from increasing production in the already highly productive Nile delta, but from avoiding losses due to the waterlogging caused by year-round irrigation from the Aswan High Dam.

Sometimes a project increases output through avoiding loss—a kind of double classification, but one that in practice causes no problem. Proposals to eradicate foot-and-mouth disease in Latin America envision projects by which the poor physical condition or outright death of animals will be avoided. At the same time, of course, beef production would be increased.

Other kinds of tangible benefits

Although we have touched on the most common kinds of benefits from agricultural projects, those concerned with agricultural development will find other kinds of tangible, direct benefits most often in sectors other than agriculture. Transport projects are often very important for agricultural development. Benefits may arise not only from cost reduction, as noted earlier, but also from time savings, accident reduction, or development activities in areas newly accessible to markets. If new housing for farmers has been included among the costs of a project, as is often the case in land settlement and irrigation projects, then among the benefits will be an allowance for the rental value of the housing. Since this is an imputed value, there are valuation problems that will be noted later.

Secondary Costs and Benefits

Projects can lead to benefits created or costs incurred outside the project itself. Economic analysis must take account of these external, or secondary, costs and benefits so they can be properly attributed to the project investment. (Of course, this applies only in economic analysis; the problem does not arise in financial analysis.)

When market prices are used in economic analysis, as has been the custom in the United States for water resource and other public works projects, it is necessary to estimate the secondary costs and benefits and then add them to the direct costs and benefits. This is a theoretically difficult process, and one easily subject to abuse. There is an extensive and complex literature on secondary costs and benefits that specifically addresses this analytical approach. For those who would like to review this literature, a good place to begin is the article by Prest and Turvey (1966), which outlines the historical development of the discussion. A highly technical review of the arguments can be found in Mishan (1971).

Instead of adding on secondary costs and benefits, one can either adjust the values used in economic analysis or incorporate the secondary costs and benefits in the analysis, thereby in effect converting them to direct costs and benefits. This is the approach taken in most project analyses carried out by international agencies, in the systems based on shadow prices proposed in more recent literature on project analysis, and in the analytical system presented here.

Incorporating secondary costs or benefits in project analysis can be viewed as an analytical device to account for the value added that arises outside the project but is a result of the project investment. In the analytical system here, as will be explained in more detail in chapter 7, every item is valued either at its opportunity cost or at a value determined by a consumer's willingness to pay for the item. The effect is to eliminate all transfers—both the direct transfers discussed earlier in this chapter and the indirect transfers that arise because prices differ from opportunity costs. By this means we attribute to the project investment all the value added that arises from it anywhere in the society. Hence, it is not necessary to add on the secondary costs and benefits separately; to do so would constitute double counting.

One qualification must be made. If a project has a substantial effect on the quantity other producers are able to sell in imperfect markets—and most markets are imperfect—there may be gains or losses not accurately accounted for. Squire and van der Tak (1975, p. 23) cite the example of an improved road that diverts traffic from a railway that charges rates below marginal cost. This diversion entails a social gain from reduced rail traffic (in avoiding the social losses previously incurred on this traffic) in addition to the benefits to the road users measured directly. In agricultural projects, this is a rather infrequent case because prices generally are more flexible than in other sectors of the economy. In any event, in the practice of contemporary project analysis the size of these gains or losses is generally assumed to be insignificant, and no provision is made for them in the analysis.

Although using shadow prices based on opportunity costs or willingness to pay greatly reduces the difficulty of dealing with secondary costs and benefits, there still remain many valuation problems related to goods and services not commonly traded in competitive markets. One way to avoid some of these problems is to treat a group of closely related investments as a single project. For example, it is common to consider the output of irrigation projects as the increased farm production, since valuing irrigation water is difficult. Another example is found in development roads built into inaccessible areas. It is argued that the production arising from the induced investment activities of otherwise unemployed new settlers should be considered a secondary benefit of the road investment. One way of avoiding the problem is to view this case as a land settlement project in which the road is a component. New production is then properly included among the direct benefits of the project and can be included in the project accounts at market or shadow prices, and no attempt need be made to allocate the benefits between road investment

and the other kinds of investment that must be made by settlers and government if settlement is to succeed.

Another group of secondary costs and benefits has been called "technological spillover" or "technological externalities." Adverse ecological effects are a common example, and the side effects of irrigation development are often cited as an illustration. A dam may reduce river flow and lead to increased costs for dredging downstream. New tubewell development may have adverse effects on the flow of existing wells. Irrigation development may reduce the catch of fish or may lead to the spread of schistosomiasis. When these technological externalities are significant and can be identified and valued, they should be treated as a direct cost of the project (as might be the case for reduced fish catches), or the cost of avoiding them should be included among the project costs (as would be the case for increased dredging or for investment to avoid pollution).

It is sometimes suggested that project investments may give rise to secondary benefits through a "multiplier effect." The concept of the multiplier is generally thought of in connection with economies having excess capacity. If excess capacity exists, an initial investment might cause additional increases in income as successive rounds of spending reduce excess capacity. In developing countries, however, it is shortage of capacity that is characteristic. Thus, there is little likelihood of excess capacity giving rise to additional benefits through the multiplier. In any event, most of the multiplier effect is accounted for if we shadow-price at opportunity cost. Since the opportunity cost of using excess capacity is only the cost of the raw materials and labor involved, only variable costs will enter the project accounts until existing excess capacity is used up.

It is also sometimes suggested that there is a "consumption multiplier effect" as project benefits are received by consumers. Consumption multipliers are very difficult to identify and value. In any case, they presumably would be much the same for alternative investments, so omitting them from a project analysis would not affect the relative ranking of projects.

Intangible Costs and Benefits

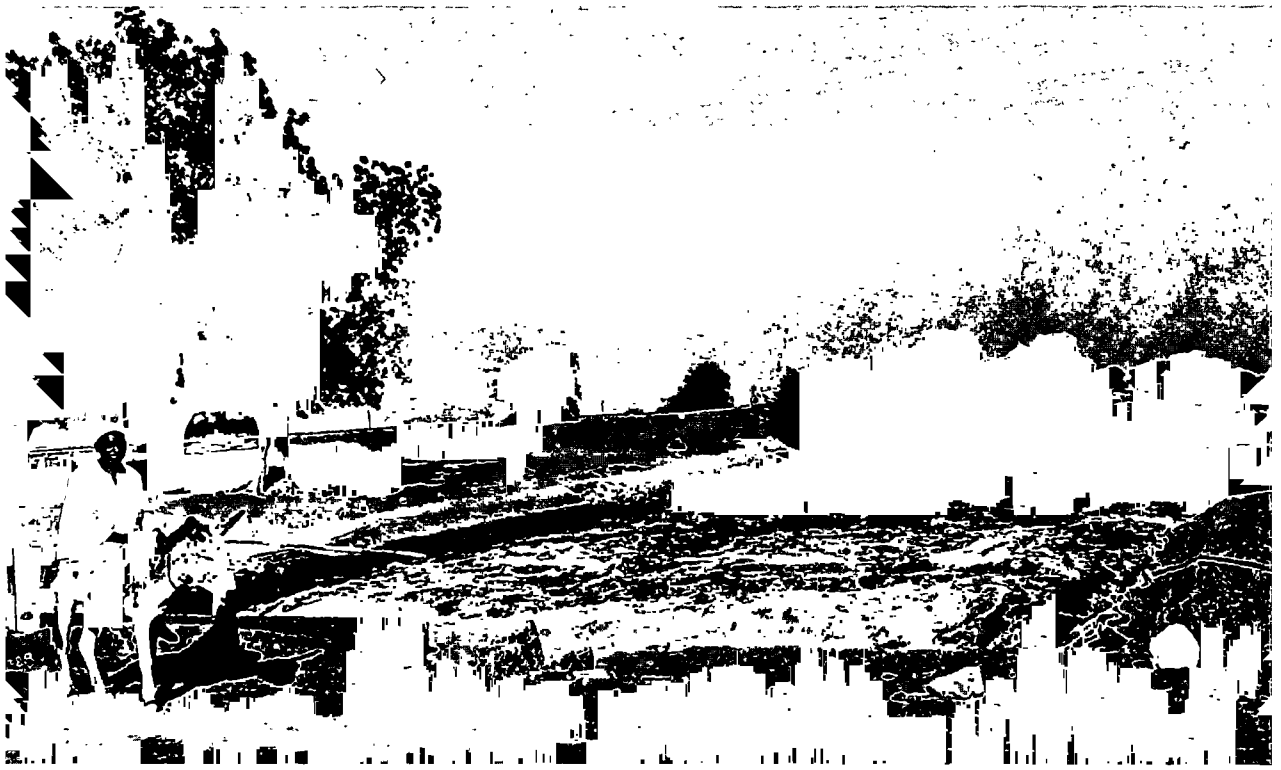
Almost every agricultural project has costs and benefits that are intangible. These may include creation of new job opportunities, better health and reduced infant mortality as a result of more rural clinics, better nutrition, reduced incidence of waterborne disease as a result of improved rural water supplies, national integration, or even national defense. Such intangible benefits are real and reflect true values. They do not, however, lend themselves to valuation. How does one derive a figure for the long-term value of a child's life saved, or for the increased comfort of a population spared preventable, debilitating disease? Benefits of this kind may require a modification of the normal benefit-cost analysis to a least-cost type of analysis, a topic we will take up when we discuss valuation. Because intangible benefits are a factor in project selection, it

is important that they be carefully identified and, where at all possible, quantified, even though valuation is impossible. For example, how many children will enroll in new schools? How many homes will benefit from a better system of water supply? How many infants will be saved because of more rural clinics?

In most cases of intangible benefits arising from an agricultural project, the costs are tangible enough: construction costs for schools, salaries for nurses in a public health system, pipes for rural water supplies, and the like. Intangible costs, however, do exist in projects. Such costs might be incurred if new projects disrupt traditional patterns of family life, if development leads to increased pollution, if the ecological balance is upset, or if scenic values are lost. Again, although valuation is impossible, intangible costs should be carefully identified and if possible quantified. In the end, every project decision will have to take intangible factors into account through a subjective evaluation because intangible costs can be significant and because intangible benefits can make an important contribution to many of the objectives of rural development.

PART TWO

Financial Aspects of Project Analysis



3

Pricing Project Costs and Benefits

ONCE COSTS AND BENEFITS have been identified, if they are to be compared they must be valued. Since the only practical way to compare differing goods and services directly is to give each a money value, we must find the proper prices for the costs and benefits in our analysis.

Prices Reflect Value

Underlying all financial and economic analysis is an assumption that prices reflect value—or can be adjusted to do so. In this chapter we will discuss how to find these prices. Before proceeding, however, it is necessary to define two economic concepts crucial to project analysis: marginal value product and opportunity cost.

Consider a Filipino farmer who applies nitrogenous fertilizer to his rice. In the 1979–80 season this fertilizer cost him ₱3.98 per kilogram of elemental nitrogen (N), and he received ₱1.050 for every kilogram of paddy rice he sold. (The symbol for Philippine pesos is ₱.) Table 3-1 shows the responsiveness of his rice to fertilizer. At low levels of application, fertilizer has a great effect on rice yield. Increasing the application from no fertilizer to 10 kilograms of elemental nitrogen increased the farmer's

Facing page: Crossing an irrigation canal in Sudan.

Table 3-1. *Crop Response to Nitrogen Fertilizer in the Philippines*

	Paddy rice			*Shelled maize*		
Nitrogen[a] *(kilograms per hectare)*	*Yield (kilograms per hectare)*	*Value*[b] *(₱)*	*Marginal value product*[c] *(₱)*	*Yield (kilograms per hectare)*	*Value*[d] *(₱)*	*Marginal value product (₱)*
0	3,442	3,614		2,600	2,688	
			29.50			23.80
10	3,723	3,909		2,830	2,926	
			26.10			21.70
20	3,971	4,170		3,040	3,143	
			22.60			19.70
30	4,187	4,396		3,230	3,340	
			19.20			17.60
40	4,370	4,588		3,400	3,516	
			15.80			15.50
50	4,520	4,746		3,550	3,671	
			12.30			13.40
60	4,637	4,869		3,680	3,805	
			8.80			11.40
70	4,721	4,957		3,790	3,919	
			5.40			9.30
80	4,772	5,011		3,880	4,012	
			2.00			7.20
90	4,791	5,031		3,950	4,084	
			−1.50			5.20
100	4,777	5,016		4,000	4,136	
			[e]			3.10
110				4,030	4,167	
						1.00
120				4,040	4,177	
						−1.00
130				4,030	4,167	

₱ Philippine pesos.

Source: Personal communication from Pedro R. Sandoval, University of the Philippines at Los Baños, September 1980. Rice responses are based on *Changes in Rice Farming in Selected Areas of Asia* (Manila: International Rice Research Institute, 1978), p. 61. Maize responses are based on University of the Philippines at Los Baños Experiment Station records. Prices are from the Bureau of Agricultural Economics, Ministry of Agriculture, Republic of the Philippines.

a. The farm-gate price of elemental nitrogen (N) in 1979–80 was ₱3.98 per kilogram.

b. The farm-gate price of paddy rice in 1979–80 was ₱1.050 per kilogram.

c. The marginal value product is the extra revenue that comes from increasing the quantity of an input used by one unit, all other quantities remaining constant. In this instance, the marginal value product is the increased value of paddy rice or shelled maize from using 1 additional kilogram of elemental nitrogen. Note that in this table the interval between levels of elemental nitrogen is 10 kilograms. Thus, the marginal value product of elemental nitrogen applied to rice between the 60- and 70-kilogram levels of application is the difference in value of output between the two levels divided by 10, or ₱8.80 [(4,957 − 4,869) ÷ 10 = 8.80].

d. The farm-gate price of shelled yellow maize in 1979–80 was ₱1.034 per kilogram.

e. Beyond application of 100 kilograms of elemental nitrogen, all marginal value products for paddy rice are negative; therefore, figures for these applications of nitrogen to rice are not reported.

yield from 3,442 kilograms to 3,723 kilograms per hectare and increased the value of his output by ₱295, from ₱3,614 to ₱3,909. Thus, for every additional kilogram of elemental nitrogen the farmer applied at this level, he received ₱29.50 in return [(3,909 − 3,614) ÷ 10 = 29.50]. The extra revenue from increasing the quantity of an input used, all other quantities remaining constant, is the marginal value product of the input. In this case, then, the marginal value product of a kilogram of fertilizer is ₱29.50.

If the farmer could buy fertilizer for ₱3.98 a kilogram and use it to increase output by ₱29.50, it obviously would have paid him to apply

more. But as the intensity of application increases, each additional kilogram of fertilizer has less and less effect on production. If the farmer had increased his application from 80 to 90 kilograms per hectare, he would have increased the value of his production by only ₱20, from ₱5,011 to ₱5,031, and the marginal value product of a kilogram of fertilizer would have fallen to only ₱2.00 [(5,031 − 5,011) ÷ 10 = 2.00]. Since he would have had to pay ₱3.98 per kilogram, it clearly would not have been worthwhile to apply fertilizer at this rate. In fact, it would only have paid the farmer to apply fertilizer up to the rate at which the marginal value product just equaled the price. For this Filipino farmer, it would have paid him to apply approximately 80 kilograms of nitrogen: between 70 and 80 kilograms the marginal value product of each additional kilogram was some ₱5.40, whereas between 80 and 90 kilograms it fell to ₱2.00. Thus, the farmer would have expanded his fertilizer use until he reduced the marginal value product of the fertilizer to its market price, and the market price, therefore, is an estimate of the marginal value product of the fertilizer.

The optimal amount of fertilizer to use will change, of course, when the price of fertilizer changes relative to the price of rice. If the relative price of fertilizer were to rise, the farmer would respond by reducing the amount of fertilizer he applies, increasing the marginal value product of the fertilizer (but reducing the total amount and value of production) until the marginal value product of the fertilizer again just equals its price. Suppose fertilizer were to double in price to ₱8.00 per kilogram of elemental nitrogen, and rice prices remained unchanged. Then, table 3-1 indicates the farmer should reduce the amount of fertilizer applied to a hectare from 80 kilograms to 70 kilograms, since between 60 and 70 kilograms the marginal value product was some ₱8.80 but between 70 and 80 kilograms it was only some ₱5.40.

In practice, because of risk and limited resources, the farmer would probably not have applied the amounts indicated here. We may consider that the farmer reduces his expected return by some "risk discount." Even so, the principle we are illustrating remains the same: the farmer equates the expected marginal value product less some risk discount to the price of fertilizer.

If this farmer also grew maize, for which in 1979–80 he would have received ₱1.034 per kilogram of shelled grain, table 3-1 indicates it would have paid him (in the absence of risk) to apply some 100 kilograms of elemental nitrogen to each hectare, because between 90 and 100 kilograms the marginal value product of a kilogram of nitrogen applied to maize was ₱5.20, whereas between 100 and 110 kilograms the marginal value product fell to ₱3.10, below the price of fertilizer.

Now, suppose the farmer had limited resources and could not obtain sufficient credit to increase his fertilizer application on both rice and maize to where the marginal value product equaled the price. Suppose the farmer had only 2 hectares, 1 planted in rice and 1 in maize, and resources sufficient to purchase just 80 kilograms of nitrogen. How should he have used it? Should he have put it all on rice and none on

maize? If he did, he would have applied fertilizer to his rice at the level where the marginal value product was just about equal to its market price. But suppose he had shifted some fertilizer, instead, to maize. If he had shifted 10 kilograms, he would have reduced the value of his rice production by ₱54—from ₱5,011 to ₱4,957, or by ₱5.40 for each kilogram shifted—but he could have obtained some ₱238 for the 10 kilograms applied to maize, since the marginal value product between 0 and 10 kilograms was some ₱23.80 per kilogram. In other words, at these levels each kilogram of nitrogen shifted would reduce the rice value by ₱5.40 but increase the value of maize output by some ₱23.80. In the language of economics, the opportunity cost of fertilizer shifted from rice to maize was ₱5.40. Opportunity cost, thus, is the benefit forgone by using a scarce resource for one purpose—in this case applying fertilizer to maize—instead of for its best alternative use—in this case using the fertilizer to produce rice. Said another way, the opportunity cost is the return a resource can bring in its next best alternative use. What would be the opportunity cost if the farmer were to move a kilogram of fertilizer in the other direction, back from maize to rice? He would have given up ₱23.80 to gain only ₱5.40—not a very attractive proposition—and the opportunity cost, obviously, would be some ₱23.80.

Given his limited resources, it would pay the farmer to shift fertilizer from rice to maize until the marginal value product of fertilizer applied to both crops is the same. In the case of the Filipino farmer who could buy only 80 kilograms of fertilizer, if on the one hand he were to move 40 kilograms to maize, reducing his application on rice from 80 kilograms to 40 kilograms, he would have increased the marginal value product of the fertilizer on his rice to some ₱15. On the other hand, the 40 kilograms shifted away from rice and put on maize would have decreased the marginal value product of nitrogen applied to maize also to about ₱15. At these levels, there would be no advantage in shifting fertilizer between the two crops—the opportunity cost of shifting more fertilizer from rice to maize would be about ₱15, but the gain would also be only about ₱15—and the farmer would have reached the optimal level of application to both crops.

Note, however, that if the farmer could somehow have bought as much fertilizer as he wanted at the market price of ₱3.98 per kilogram—perhaps through a credit program—then the market price of fertilizer would have become its opportunity cost, and (in the absence of a risk discount) he should have increased his application to 80 kilograms on rice and 100 kilograms on maize.

From a single farmer to the economy as a whole, the same principles apply. In a "perfect" market—one that is highly competitive, with many buyers and sellers, all of whom have perfect knowledge about the market—every economic commodity would be priced at its marginal value product, since every farmer will have expanded his fertilizer use to where its marginal value product equals its price, and the same will have happened for every other item in the economy. That is, the price of every good and service would exactly equal the value that the last unit utilized

contributes to production, or the value in use of the item for consumption would exactly balance the value it could contribute to additional production. If a unit of goods or services could produce more or bring greater satisfaction in some activity other than its present use, someone would have been willing to bid up its price, and it would have been attracted to the new use. When this price system is in "equilibrium," the marginal value product, the opportunity cost, and the price will all be equal. Resources will then have been allocated through the price mechanism so that the last unit of every good and service in the economy is in its most productive use or best consumption use. No transfer of resources could result in greater output or more satisfaction.

Without moving further into price theory, we can consider some direct implications for agricultural projects of the assumption that prices reflect value.

First, as everyone knows, markets are not perfect and are never in complete equilibrium. Hence, prices may reflect values only imperfectly. Even so, there is a great deal of truth in this price theory based on the model of perfect markets. In general, the best approximation of the "true value" of a good or service that is fairly widely bought and sold is its market price. Somebody in the economy is willing to pay this price. One can presume that this buyer will use the item to increase output by at least as much as its price, or that he is willing to exchange something of value equal to the price to gain the satisfaction of consuming the item. Hence, the market price of an item is normally the best estimate of its marginal value product and of its opportunity cost, and most often it will be the best price to use in valuing either a cost or a benefit. In financial analysis, as we have noted, the market price is always used. But in economic analysis some other price—a "shadow price"—may be a better indicator of the value of a good or service; that is, a better estimate of its true opportunity cost to the economy. When prices other than market prices are used in economic analysis, however, the burden of proof is on the analyst.

Finding Market Prices

Project analyses characteristically are built first by identifying the technical inputs and outputs for a proposed investment, then by valuing the inputs and outputs at market prices to construct the financial accounts, and finally by adjusting the financial prices so they better reflect economic values. Thus, the first step in valuing costs and benefits is finding the market prices for the inputs and outputs, often a difficult task for the economist.

To find prices, the analyst must go into the market. He must inquire about actual prices in recent transactions and consult many sources—farmers, small merchants, importers and exporters, extension officers, technical service personnel, government market specialists and statisticians, and published or privately held statistics about prices for both

national and international markets. From these sources the analyst must come up with a figure that adequately reflects the going price for each input or output in the project.

Point of first sale and farm-gate price

In project analysis, a good rule for determining a market price for agricultural commodities produced in the project is to seek the price at the "point of first sale." If the point of first sale is in a relatively competitive market, then the price at which the commodity is sold in this market is probably a relatively good estimate of its value in economic as well as financial terms. If the market is not reasonably competitive, in economic analysis the financial price may have to be adjusted better to reflect the opportunity cost or value in use of the commodity.

For many agricultural projects in which the objective is increased production of a commodity, the best point of first sale to use is generally the boundary of the farm. We are after what the farmer receives when he sells his product—the "farm-gate" price. The increased value added of the product as it is processed and delivered to a market arises as a payment for marketing services. This value added is not properly attributed to the investment to produce the commodity. Rather, it arises from the labor and capital engaged in the marketing service. Usually the price at point of first sale can be accepted as the farm-gate price; even if this point is in a nearby village market, the farmer sells his output there and thus earns for himself any fee that might be involved in transporting the commodity from the farm to the point of first sale. But if any new equipment is necessary to enable the farmer to do this—say, a new bullock cart or a new truck—then that new equipment must be shown as a cost incurred to realize the marketing benefit in the project.

In projects producing commodities for well-organized markets, the farm-gate price may not be too difficult to determine. This would be true for most food grains traded domestically in substantial quantities. One may think of wheat in most countries of the Middle East and South Asia, of rice in South and Southeast Asia, and of maize in much of Latin America. It would also be true of farm products for which the processor is generally the first buyer (such as fresh fruit bunches for palm oil in Malaysia or milk in Jamaica), where the price quoted to the farmer is the price on his farm, and the firm responsible for the marketing comes to the farm to pick up the product.

In many cases, however, the prices in a reasonably competitive market or in the price records kept by the government statistical service will include services not properly attributable to the investment in the project itself. This may happen, for instance, when the only price series available for a product records the prices at which it has been sold in a central market—such as the price for eggs in Madras, for melons in Tehran, or for vegetables in Bogota. In that case, the project analyst will have to dig deeper to find out how to value the marketing services. Then he can adjust the central market price to reduce it to the farm-gate price.

The farm-gate price is generally the best price at which to value home-consumed production. In some cases it may be extremely difficult to determine just what a realistic farm-gate price is for a crop produced primarily for home consumption because so little of the crop appears on markets. This is the case, for example, for manioc and cocoyam in Africa. On the one hand, some argue that the true value of the crop is overstated if the market price is used as a basis for valuation because such a small proportion of the product is actually sold. On the other hand, the same crop in different situations may not be so difficult to value. Manioc is sold extensively in Nigeria to make *gari* flour, and it is commonly traded in local markets in tropical Latin America and the Caribbean.

The farm-gate price may be a poor indicator of the true opportunity cost we want to use in economic analysis. In Ghana the Marketing Board takes some proportion of the cocoa price as a tax for development purposes. In Thailand, a rice "premium"—that is, a tax on rice exports—effectively keeps the domestic price well below what the international market would pay. In these cases, when the commodity is traded its economic value would have to be considered higher than the actual farm-gate price, and this price distortion will have to be corrected in the economic analysis. In other cases, just the opposite happens. In Mexico the price of maize is maintained at a high level to transfer income to *ejidatarios*, the small farmers. In Malaysia, the price of rice is supported above world market levels to encourage local production and to reduce imports. In these cases, part of the price does not really reflect the economic value of the product—its cost if it could be imported—but rather an indirect income transfer to small farmers. Again, this price distortion will have to be corrected in the economic analysis.

Pricing intermediate goods

By emphasizing the point of first sale as a starting point for valuing the output of our projects, we are also implying that imputed prices should be avoided for intermediate goods in our analysis. An intermediate good is an item produced primarily as an input in the production of another good. If an intermediate good is not freely traded in a competitive market, we cannot expect to obtain a price established by a range of competitive transactions. Fodder produced on a farm and then fed to the dairy animals on the farm is an example of such an intermediate product. If increased fodder production is an element in the proposed agricultural project, the analyst would avoid valuing it. Instead, the analyst would treat the whole farm as a unit and value the milk produced at its point of first sale or value the calves sold as feeder cattle. Treatment of intermediate products will vary from project to project depending on the particular marketing structures. In some countries it would hardly make sense in an egg production project to value the pullets produced in a pullet production enterprise and then "sell" these pullets to the egg production enterprise on the same farm. But in other countries there might be an active market in pullets, which would mean that we could expect to find a

reasonably competitive price to use in the economic analysis. To avoid most of the problems that might be introduced by trying to impute values for intermediate products, the financial accounts in agricultural projects are based on budgets for the whole farm instead of on budgets for individual activities on the farm; that is, on the budget for the egg farm as a whole rather than on the budget for a pullet production activity.

A frequently encountered intermediate good in agricultural projects is irrigation water. The "product" of an irrigation system—water—is, of course, really intended to produce agricultural commodities. The price farmers are charged for the water is generally determined administratively, not by any play of competitive market forces. If the analyst were to try to separate the irrigation system from the production it makes possible, he would be faced with a nearly impossible task of determining the value of irrigation water. Hence, it is not surprising that the economic analyses of most irrigation projects take as the basis for the benefit stream the value of the agricultural products that *are* offered in a relatively free market at the point of first sale.

Other problems in finding market prices

Considerable confusion often arises in determining the values for two important inputs in agricultural projects, land and labor. This happens primarily when the analysis moves from the financial project accounts to the economic analysis (to which we will turn in chapter 7). In the accounts prepared for the financial analysis, the treatment of prices for land and labor is quite straightforward: the price used is the price actually paid. Thus, if the farmers in a settlement project are expected to pay the project authority a price for the land they acquire, perhaps through a series of installments, then the actual price in the year it is paid is entered in the project accounts. In the *financial* analysis, we do not question whether this is a "good" price in economic terms. Similarly, if land must be bought for the right-of-way for canals in an irrigation project, the actual price to be paid is entered in the project accounts in the financial analysis. Or, if the project includes tenant farmers who will receive help in increasing wheat production, then in the financial accounts for these tenant farmers the analyst will enter the rent paid each year at the amount actually paid, or at the farm-gate value of the wheat delivered to the landowner if the tenants pay rent in kind.

If farm accounts are laid out on a with-and-without basis following the format suggested in chapter 4, in those instances where the project involves only changing the cropping pattern (say, a shift from pasture to irrigated sorghum), the cost of the land (in this instance an opportunity cost) need not be separately entered because of the form of the account. When the net benefit without the project is subtracted from the net benefit with the project, the contribution of the land to the old cropping pattern is also subtracted and only the incremental value remains.

In valuing labor for the financial analysis accounts, again, the problems arise when the financial accounts are adjusted to reflect economic

values. For financial analysis, the analyst enters the amounts actually paid to hired labor, either in wages or in kind, in the farm budgets or project accounts. Family labor is treated differently. It is not entered as a cost; instead, the "wages" for the family become a part of the net benefit. Thus, if our project increases the net benefit, it also in effect increases the family's income or "wages" for its labor. Again, if we follow the format suggested in chapter 4, the account will automatically value the family labor at its opportunity cost, and the incremental net benefit will reflect any increased return the family may receive for its labor.

Prices for agricultural commodities generally are subject to substantial seasonal fluctuation. If this is the case, some decision must be made about the point in the seasonal cycle at which to choose the price to be used for the analysis. A good starting point is the farm-gate price at the peak of the harvest season. This is probably close to the lowest price in the cycle. The line of reasoning here is that as prices rise during the cycle at least some part of that rise is a result not of the production activities of the farmer but of the marketing services embodied in storing the crop until consumers want it. But, markets being what they are, there may be an element of imperfection in the harvest price level. Market channels may become so glutted that merchants try actively to discourage farmers from immediately bringing their crop to the market by offering a price that even the merchants themselves would admit is too low. Even so, the need to sell immediately to meet debt obligations may force farmers to offer their crops despite these artificially low, penalty prices. In some cases, therefore, a price higher than the farm-gate price in the harvest season may be selected. But there is an obligation here to justify the price chosen as more valid than the lowest seasonal price. One way to resolve this problem may be to include an element of credit in the project design. This would permit farmers to withhold their product from the market until prices have had a chance to rise from their seasonal lows but at the same time to have enough money to meet their cash obligations and family living expenses. The credit element may also include credit for building on-farm storage so that farmers will have a safe place to store their production until they decide to market it at a better price.

Prices vary among grades of product, of course, and picking the proper price for project analysis may involve making some decisions about quality of the product. In general, it can be assumed that farmers will produce in the future much the same quality as they have in the past and will market their product ungraded. In many agricultural projects, however, one objective is to upgrade the quality of production as well as to increase the total output. Small dairy farmers, for instance, may be able with the help of the project investment to meet the sanitation standards of the fluid milk market and to command a higher price; or reduced time for delivery may hold down sucrose inversion in sugarcane; or better pruning will increase the average size of the oranges Moroccan farmers can offer European buyers. In such cases, the proper price to select is the average price expected for the quality to be produced.

A special problem occurs in pricing housing. If project investment

includes housing construction, as would be the case for a settlement project, then one benefit arising from the investment is the rental value of the house. Since the rental value will usually be an imputed value rather than a real market price, care must be exercised in determining it. No more should be allowed for the rental value than would normally be paid by a prospective tenant family. Nor should more rental value be allowed than the family would be expected to pay for a comparable house in the vicinity or in a similar area elsewhere (if the new settlement is in a distant locale). In particular, the temptation should be avoided to take as a rental value some arbitrary proportion of the housing cost. Otherwise, overly elaborated housing construction might be justified simply by assigning it an unrealistically high imputed value.

Project boundary price

Prices used in analyzing agricultural projects are not necessarily farm-gate prices. The concept of a farm-gate price may be expanded to a "project boundary" price if a project has a marketing component or if it is a purely marketing project. Many projects have a marketing component, perhaps because there is no competitive channel reaching down to the farm-gate level for the unprocessed product. Of concern in these projects are both the farm-gate price (on which to base the estimates of the net benefit to the farmer) and the price at which the processed product is sold in the market (after being handled in the facilities financed by the project). Such a case is found in the Rahad project in the Sudan. There the Roseires dam on the Blue Nile will provide irrigation water for the production of cotton, which will be ginned in new facilities financed by the project. The analyst, of course, is interested in the price of cotton paid to the farmers so that their incomes can be estimated. But, since this price is set administratively, it could not be used directly in the economic analysis of the project. The analyst is also interested in the price of ginned cotton because that is the first product the project will actually sell in a reasonably competitive market. In this case, the point of first sale is f.o.b. (free on board) Port Sudan, and the price there becomes the basis for the benefit stream.

Predicting Future Prices

Since project analysis is about judging future returns from future investment, as analysts we are immediately involved in judging just what future prices may be. This is a matter of judgment, not mechanics. No esoteric mathematical model exists to come to the aid of the project analyst; like everyone else he must take into consideration all the facts he can find, seek judgments from those he respects, and then come to a conclusion himself. It tends to be a rather unsettling process. The only consolation is that careful, considered judgment about the course of

future prices is better than giving the matter no thought at all and wasting scarce resources on incompletely planned projects.

We have been discussing how to find market prices, and it is from these current prices that we begin. The best initial guess about future prices is that they will retain the present relationships, or perhaps the average relationship they have borne to each other over the past few years. We must consider, however, whether these average relationships will change in the future and how we will deal with a general increase in the level of prices owing to inflation.

Changes in relative prices

We may first raise the question of whether *relative* prices will change. Will some inputs become more expensive over time in relation to other commodities? Will some prices fall relatively as supplies become more plentiful? Not easy questions to deal with, but some approaches to answers can be made. In financial analysis, of course, a change in a relative price means a change in the market price structure that producers face either for inputs or for outputs. A change in a relative price, then, is reflected directly in the project's financial accounts. A rise in the relative price of fertilizer reduces the incremental net benefit—the amount the farm family has to live on. It is thus clearly a cost in the farm account. The same line of reasoning can be applied in the financial analysis for any other group participating in the project.

A change in the relative price of an item implies a change in its marginal productivity—that is, a change in its marginal value product—or a change in the satisfaction it contributes when it is consumed. In economic analysis, where maximizing national income is the objective, a change in the relative price of an input implies a change in the amount that must be forgone by using the item in the project instead of elsewhere in the economy; it is therefore a change in the contribution the output of the project makes to the national income. Thus, changes in relative prices have a real effect on the project objective and must be reflected in project accounts in the years when such changes are expected.

There are several kinds of commodities subject to future changes in relative prices. Most agricultural project analysts would probably agree that the relative price of energy-intensive agricultural inputs is likely to continue to rise over the next several years, just as it has done over the past few years. Thus, on the input side the project accounts might show an annual increase, at least for the first decade or so, in the cost of fuel for tractors, for transporting the harvested crop, for drying grain, and for such petroleum-based inputs as fertilizers and chemical pesticides. On the output side, there may be some commodities that will probably continue to be in short supply and whose prices will rise as incomes increase—one might think of mutton from fat-tailed sheep in Iran, or, for that matter, of most meat products worldwide. How much will prices increase relative to those of other products? Certainly a difficult ques-

tion, but one the project analyst must confront. For a range of products—from industrial crops such as fibers or oilseeds to food grains and vegetables—judgments will have to be made on the best possible basis.

In some countries, relative wages of rural labor may rise as economic development proceeds during the life of a project. This will have implications not only for the prices assumed for hired labor, but also for the incentive effect exerted by a given change in net benefit and for the technology assumed as a basis for projections in the farm budgets and project accounts.

Inflation

In the past few years, virtually every country has experienced inflation, and the only realistic assessment is that this will continue. No project analyst can escape deciding how to deal with inflation in his analysis.

The approach most often taken is to work the project analysis in constant prices. That is, the analyst assumes that the current price level (or some future price level—say, for the first year of project implementation) will continue to apply. It is assumed that inflation will affect most prices to the same extent so that prices retain their same general relations. The analyst then need only adjust future price estimates for anticipated relative changes, not for any change in the general price level. By comparing these estimates of costs and benefits with the constant prices, he is able to judge the effects of the project on the incomes of participants and its income-generating potential for the society as a whole. Although the absolute (or money) values of the costs and benefits in both the financial and the economic analyses will be incorrect, the general relations will remain valid, and so the measures of project worth discussed in chapter 9 may be applied directly. Working in constant prices is simpler and involves less calculation than working in current prices; for the latter, every entry has to be adjusted for anticipated changes in the general price level.

It is quite possible, however, to work the whole project analysis in current prices. This has the advantage that all costs and benefits shown would be estimates of what the real prices will be in each year of the project. Furthermore, estimates of investment costs will be in current terms for the year in which they are expected to occur, so that the finance ministry can more easily anticipate these needs and budget the amounts necessary to finance the project on schedule. The problem in this approach is that it involves predicting inflation rates. For items to be imported, some help is available in the World Bank report on *Price Prospects for Major Primary Commodities* (1982*a*), which is published biennially and updated in six-month intervals and includes an estimate of inflation in developed countries. For domestic inflation rates in developing countries, other sources will have to be consulted, but obtaining an estimate in which one can place even minimal confidence will be difficult, to say the least. Even casting the project analysis in current terms may raise problems for the project analyst. Many governments

have policy goals that call for greatly reduced inflation, and they cannot permit the circulation of official documents that assume rapid inflation will continue.

The mere mechanics of using current prices presents no analytical problem in project analysis, although it does complicate the computations. When we consider measures of project worth, some means of deflating future prices must be adopted for comparing future cost and benefit streams in terms that are free from the effects of general price increases. We will illustrate the methodology in chapter 10 in the section "Calculating Measures of Project Worth Using Current Prices."

Even when constant prices are used in the more conventional approach to project analysis, a table estimating the budgetary effects of the project in current terms that will prevail at least during the investment phase should be included either in the analysis or as a separate memorandum. It would list in current prices domestic currency needs, foreign exchange requirements, and subsidies. The finance ministry would then have better estimates to work with, and delays because of budgetary shortfalls could more easily be avoided.

Prices for Internationally Traded Commodities

For commodities that enter significantly in international trade, whether inputs or outputs, project analysts usually obtain price information from various groups of specialists who follow price trends and make projections about relative prices in the future. In many countries where agricultural exports are important, there are groups in the agriculture ministry or the finance ministry whose help may be sought.

There are also several international organizations and trade groups to which the analyst may turn. The World Bank, for instance, publishes its projections under the title *Price Prospects for Major Primary Commodities*. The Food and Agriculture Organization (FAO) sponsors intergovernmental groups that publish price information on rice; grains (other than rice); citrus; hard fibers; fibers (other than hard fibers); oilseeds, oils and fats; bananas; wine and wine products; tea; meat; and cocoa. Information may be obtained from the secretary of the relevant intergovernmental group at the FAO headquarters in Rome or from the FAO representative in individual countries.

Several international commodity organizations keep detailed price information for the products of their interest. These include the International Tea Committee, the International Cocoa Organization, the International Wool Secretariat, the International Coffee Organization, the International Association of Seed Crushers, the International Rubber Study Group, and the International Sugar Organization, all with headquarters in London; the International Olive Oil Council in Madrid; and the International Cotton Advisory Committee in Washington.

Some individual nations systematically collect production and price information for crops and livestock products of interest to them, and they

often are willing to share this information with analysts in other countries without charge or restriction. The United States Department of Agriculture—probably the most important of these—publishes detailed studies about most major crops traded in international markets. Information may be obtained from agricultural attaches in American embassies, or directly from the department's Foreign Agriculture Service. The Commonwealth Secretariat in London publishes information about price trends for commodities of interest to its member nations. A detailed list of "Sources of Information on World Prices" is available from the World Bank (Woo 1982).

Financial Export and Import Parity Prices

In projects that produce a commodity significant in international trade, the price estimates are often based on projections of prices at some distant foreign point. The analyst must then calculate the appropriate price to use in the project accounts, either at the farm gate or at the project boundary.

If the farm-gate or project boundary prices for the internationally traded commodities in the project are already known, and the prices in the particular country tend to follow world market prices, the farm-gate prices may be adjusted by the same relative amount as indicated, say, by the medium trend projected in the future relative prices supplied by one or another international organization. Also, in financial analysis, if the farm-gate price is set administratively and is not allowed to adjust freely to world prices, the relevant price to use is the administratively set price.

Simply adjusting domestic prices by the same relative amount as foreign prices often arrives at figures too rough for project analysis. The approach ignores the fact that marketing margins in commodity trade tend to be less flexible than the commodity prices themselves. There are also many instances in estimating the economic value of a traded commodity that involve deriving a shadow price based on international prices. In such instances it is necessary to calculate export or import parity prices. (See chapter 7, the subsection "Economic export and import parity values.") These are the estimated prices at the farm gate or project boundary, which are derived by adjusting the c.i.f. (cost, insurance, and freight) or f.o.b. prices by all the relevant charges between the farm gate and the project boundary and the point where the c.i.f. or f.o.b. price is quoted. The elements commonly included in c.i.f. and f.o.b. are given in table 3-2.

One common case for which an export parity price has to be calculated is that of a commodity produced for a foreign market. Table 3-3 gives an example based on the Rahad project in the Sudan. It shows the generalized elements for calculating export parity prices so that the same methodology can be applied in other cases. As noted earlier, the Rahad project included cotton gins. Since the gins produce lint and cottonseed for export and scarto, a by-product of very short fibers not suitable for

Table 3-2. *Elements of C.i.f. (Cost, Insurance, Freight) and F.o.b. (Free on Board)*

Item	*Element*
C.i.f.	*Includes*:
	F.o.b. cost at point of export
	Freight charges to point of import
	Insurance charges
	Unloading from ship to pier at port
	Excludes:
	Import duties and subsidies
	Port charges at port of entry for taxes, handling, storage, agents' fees, and the like
F.o.b.	*Includes*:
	All costs to get goods on board—but still in harbor of exporting country:
	Local marketing and transport costs
	Local port charges including taxes, storage, loading, fumigation, agents' fees, and the like
	Export taxes and subsidies
	Project boundary price
	Farm-gate price

Source: William A. Ward, "Calculating Import and Export Parity Prices," training material of the Economic Development Institute, CN-3 (Washington, D.C.: World Bank, 1977), p. 8.

export and sold locally, the analyst needed three prices. For the lint and seed estimates, he began with forecasts of the 1980 c.i.f. prices in current terms at Liverpool, which were available from World Bank publications. From these c.i.f. prices, he then deducted insurance, ocean freight, export duties, port handling costs, and rail freight from the cotton gin at the project site to Port Sudan, thus obtaining the export parity prices at the project boundary: £Sd178.650 for lint and £Sd18.097 for seed. (The symbol for Sudanese pounds is £Sd.) The price for scarto, which was not exported, was based on the prevailing domestic price.

To illustrate, we may continue to calculate the export parity price at the farm gate, although in the Rahad example, where the farm-gate price was set administratively, this calculation was not made. The computations are laid out in the part of table 3-3 that continues from the entry for "*Equals* export parity price at project boundary." Here a new issue arises. The three products that the gin produces—lint, seed, and scarto—must be converted into their seed cotton equivalents, since it is seed cotton that the farmer sells. Similar conversions have to be made in many other instances—for example, rice milling or groundnut decortication. For the Rahad project, a weighted price of £Sd83.239 for the seed cotton was calculated using a ginning outturn of 40 percent lint, 59 percent seed, and 1 percent scarto. From this weighted price were deducted the ginning, baling, and storage charges and the costs of collec-

tion and transport from the farm gate to the gin, thus arriving at the farm-gate export parity price of £Sd66.946.

A parallel computation leads to the import parity price. Here the issue is the price at which an import substitute can be sold domestically if it must compete with imports. Table 3-4 illustrates this issue with the example of maize production in Nigeria. The same example is presented diagrammatically in figure 3-1. Nigeria is a net maize importer, and the project is to produce maize for domestic consumption to replace imported maize. We begin with the f.o.b. price at the point of export—in this case U.S. ports on the Gulf of Mexico—derived from World Bank commodity estimates. To this we add freight and insurance to obtain the c.i.f. price at either Lagos or Apapa, the two Nigerian ports concerned. Then we would add any tariffs and subsidies (in this case there are none); add

Table 3-3. *Financial Export Parity Price for Cotton, Rahad Irrigation Project, Sudan*
(1980 forecast prices)

Step in the calculation	*Relevant step in the Sudanese example*	*Value per ton*		
		Lint	*Seed*	*Scarto*[a]
C.i.f. at point of import	C.i.f. Liverpool (taken as estimate for all European ports)	US$639 33	US$103.39	—
Deduct unloading at point of import *Deduct* freight to point of import *Deduct* insurance	Freight and insurance	– 39.63	– 24.73	—
Equals f.o.b. at point of export	F.o.b. Port Sudan	US$599.70	US$78.66	—
Convert foreign currency to domestic currency at official exchange rate	Converted at official exchange rate of £Sd1.000 = US$2.872	£Sd208.809	£Sd27.389	—
Deduct tariffs	Export duties	– 17.813	– 1.000	—
Add subsidies	(None)			
Deduct local port charges	Port handling cost Lint: £Sd5.564 per ton Seed: £Sd1.510 per ton	– 5.564	– 1.510	—
Deduct local transport and marketing costs from project to point of export (if not part of project cost)	Freight to Port Sudan at £Sd6.782 per ton	– 6.782	– 6.782	—
Equals export parity price at project boundary	Export parity price at gin at project site	£Sd178.650	£Sd18.097	—

Table 3-3 (*continued*)

Step in the calculation	*Relevant step in the Sudanese example*	*Value per ton*		
		Lint	*Seed*	*Scarto*[a]
Conversion allowance if necessary	Convert to seed cotton (£Sd178.650 × 0.4 + £Sd18.097 × 0.59 + £Sd110.200 × 0.01)[b]	71.460	10.677	1.102
			£Sd83.239	
Deduct local storage, transport, and marketing costs (if not part of project cost)	Ginning, baling, and storage (£Sd15.229 per ton)		− 15.229	
	Collection and internal transfer (£Sd1.064 per ton)		− 1.064	
Equals export parity price at farm gate	Export parity price at farm gate		£Sd66.946	

£Sd Sudanese pounds. US$ U.S. dollars.

Source: Adapted from World Bank, "Appraisal of the Rahad Irrigation Project," PA-139b (Washington, D.C., 1973; restricted circulation), annex 16, table 6. The format of the table is adapted from Ward, "Calculating Import and Export Parity Prices," p. 9.

a. Scarto is a by-product of very short, soiled fibers not suitable for export and is sold locally at a price of £Sd110.200 per ton.

b. Seed cotton is converted into lint, seed, and scarto assuming 1 ton of seed cotton yields 400 kilograms lint, 590 kilograms seed, and 10 kilograms scarto.

local port charges for harbor dues, fumigation, handling, and the like; and add local transport to the relevant inland market. The result is the wholesale price of imported maize. It is this wholesale price of maize in the inland market that is the focal point of our calculation. The alternative to project production is not to import the maize and transport it to the project area. Rather, the alternative is to import it and market it directly on the inland market. Thus the price the farmer can expect to receive in the absence of tariffs, subsidies, or an import ban is the wholesale price less the cost of moving his maize to the market. If the project had included processing facilities, then the relevant project boundary price would have been this wholesale price less handling costs from the processing facility to the wholesale market. In the Nigerian project, no processing facilities were included, so the relevant import parity price is the farm-gate price. As we move back from the wholesale market to the farm gate, we would have to provide for any conversion allowance. In this case none is necessary, since it is assumed that the farmer will sell shelled maize. From the wholesale price, then, we deduct local marketing costs including assembly, bags, and intermediary mar-

Table 3-4. *Financial Import Parity Price of Early-crop Maize, Central Agricultural Development Projects, Nigeria*
(1985 forecast prices in 1976 constant terms)

Steps in the calculation	*Relevant steps in the Nigerian example*	*Value per ton*
F.o.b. at point of export	F.o b. U.S. Gulf ports No. 2 U.S. yellow corn in bulk[a]	US$116
Add freight to point of import	Freight and insurance	31
Add unloading at point of import *Add* insurance	(Included in freight estimate)	
Equals c.i.f. at point of import	C.i.f. Lagos or Apapa	US$147
Convert foreign currency to domestic currency at official exchange rate	Converted at official exchange rate of ₦1 = US$1.62	₦91
Add tariffs	(None)	
Deduct subsidies	(None)	
Add local port charges	Landing and port charges (including cost of bags)	22
Add local transport and marketing costs to relevant market	Transport (based on a 350-kilometer average)	18
Equals price at market	Wholesale price	₦131
Conversion allowance if necessary	(Not necessary)	
Deduct transport and marketing costs to relevant market	Primary marketing (includes assembly, cost of bags, and intermediary margins)	− 14
	Transport (based on a 350-kilometer average)	− 18
Deduct local storage, transport, and marketing costs (if not part of project cost)	Storage loss (10 percent of harvested weight)	− 9
Equals import parity price at farm gate	Import parity price at farm gate	₦90

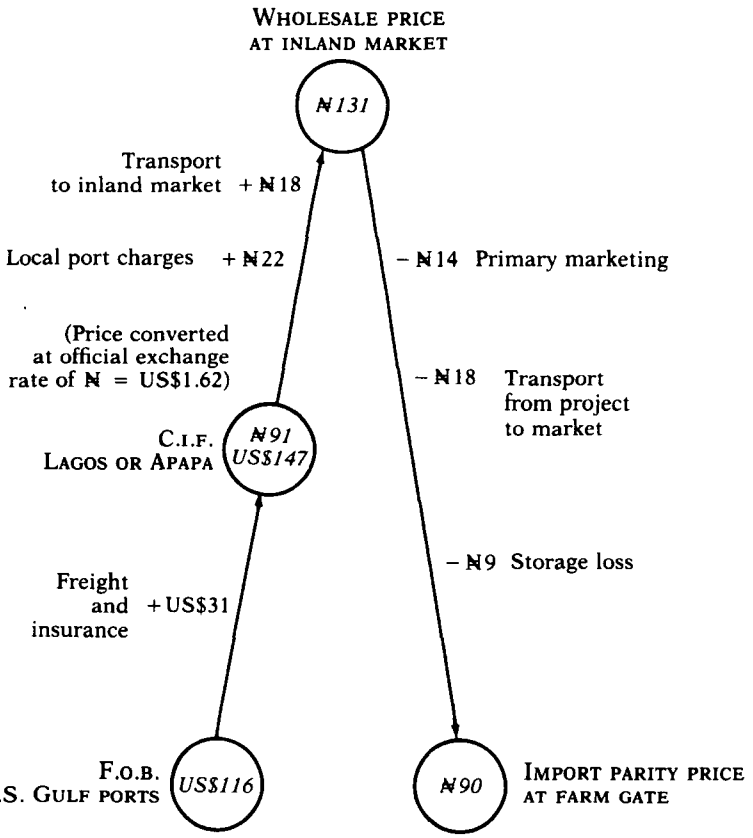
₦ Nigerian naira.

Source: Adapted from World Bank, "Supplementary Annexes to Central Agricultural Development Projects," 1370-UNI (Washington, D.C., 1976; restricted circulation), supplement 11, appendix 2, table 4. The format of the table is adapted from Ward, "Calculating Import and Export Parity Prices," p. 10.

a. Forecast from World Bank, *Price Prospects for Major Primary Commodities*, 814/76 (Washington, D.C., 1976), annex 1, p 12.

gins, transport from the farm to the market, and storage losses, thus obtaining the import parity price at the farm gate of ₦90. (The symbol for Nigerian naira is ₦.) This is the maximum price the farmer could expect to receive, again in the absence of tariffs, subsidies, or an import ban.

Figure 3-1. *Diagrammatic Derivation of Import Parity Price of Early-crop Maize, Central Agricultural Development Projects, Nigeria*
(1985 forecast prices in 1976 constant terms)



₦ Nigerian naira.
US$ U.S. dollars.
Source: Same as table 3-4.

4

Farm Investment Analysis

ONCE MARKET PRICES have been determined for those items that enter the cost and benefit streams, this information must be arranged in "pattern" accounts to begin the assessment of the effects a proposed project will have on the farmers, public and private enterprises, and government agencies that will participate in project implementation. These accounts are central to the financial analysis of agricultural projects; they are always based on market prices.

Although we will touch on the essential elements of financial analysis, much more could be taken up here. Just how elaborate the financial analysis must be for a particular project will depend on the complexity of the project. Most agricultural projects will call for a financial projection based on at least one pattern farm plan that is assumed for participating farmers. This pattern (or model) farm plan projects resource use and income flows for a group of similar farms participating in the project. The financial projections for the private and public firms or project entities may be quite summary in nature for a simply organized project, but a project in which several different firms and project entities are concerned or one that poses special financial problems may involve a much more complex analysis. The major accounts needed will be outlined in this chapter and in chapters 5 and 6, and pattern formats

Facing page: Setting out for the field in Paraguay.

suggested. This will enable the project analyst to proceed with the confidence that he is preparing an acceptable financial analysis. For more complex projects, especially those projects involving more complex public or private firms with specialized cost, revenue, or financing situations, the project analyst will have to move beyond what is discussed here. Agricultural project analysts may want to turn for more technical help to financial analysts or accountants, just as they would turn to agriculturalists or livestock technicians for their particular expertise. Many financial analysts and accountants, however, will not be familiar with methodologies of agricultural project analysis or with the particular analytical needs of the financial aspects of these projects, so even financial analysts and accountants may find that the following discussion may help them respond to a request for assistance.

Objectives of Financial Analysis

Six major objectives for financial analysis occur in analyzing agricultural projects.

Assessment of financial impact

The most important objective of financial analysis is to assess the financial effects the project will have on farmers, public and private firms, government operating agencies, and any others who may be participating in it. This assessment is based on an analysis of each participant's current financial status and on a projection of his future financial performance as the project is implemented. Detailed financial projections are needed for this analysis.

Judgment of efficient resource use

The overall return of the project and the repayment of loans extended to individual enterprises are important indicators of the efficiency of resource use. For management especially, overall return is important because managers must work within the market price framework they face. Farm investment analysis and financial ratio analysis provide the tools for this review. Project analysts and others concerned with decisions on policies for national economic growth and development will have to look beyond the financial analysis—at market prices—and form a judgment about the effects of the project on real resources for the economy as a whole. In chapter 7 we take up this issue in the discussion of how to determine economic values.

Assessment of incentives

The financial analysis is of critical importance in assessing the incentives for farmers, managers, and owners (including governments) who

will participate in the project. Will farm families have an incremental income large enough to compensate them for the additional effort and risk they will incur? Will private sector firms earn a sufficient return on their equity investment and borrowed resources to justify making the investment the project requires? For semipublic enterprises, will the return be sufficient for the enterprises to maintain a self-financing capability and to meet the financial objectives set out by the society?

Provision of a sound financing plan

A principal objective of the financial analysis is to work out a plan that projects the financial situation and sources of funds of the various project participants and of the project itself. The financial plan provides a basis for determining the amount and timing of investment by farmers and for setting repayment terms and conditions for the credit extended to support the investment. It provides the same basis for an assessment of the investment plans and debt repayment capacities of public and private firms participating in the project. Finally, for the project as a whole, the financial plan is the basis for determining the amount and timing of outside financing—whether from the national treasury or from international sources—and for establishing how rapidly the borrowed resources should be repaid. The estimated effect of inflation on both revenues and costs should be taken into account in making this assessment.

Coordination of financial contributions

The financial plan allows the coordination of the financial contributions of the various project participants. The coordination is made on the basis of an overall financial projection for the project as a whole. It addresses itself to such questions as whether the availability of resources from the treasury or international agency is matched with farmers' investment capacities and available funds for investment and operating expenses as well as with the timing of expenditures for project investments such as feeder roads and irrigation structures and for working capital needed for stocks in processing industries and the like.

Assessment of financial management competence

On the basis of a projection of the pattern financial accounts, especially for the larger firms and project entities, the analyst can form a judgment about the complexity of the financial management the project will require and about the capability of those who will manage the project's implementation. And from this assessment, the analyst can then judge what changes in organization and management may be necessary if the project is to proceed on schedule and what specialized training may be advisable.

Table 4-1. *Differences between Farm Income Analysis, Funds Flow Analysis, and Farm Investment Analysis*

Item	*Farm income analysis*	*Funds flow analysis*[a]	*Farm investment analysis*[b]
General objective	Check current performance of farm	Check farmer's liquidity	Check attractiveness of additional investment
Period usually analyzed	Individual years	Loan repayment period	Useful life of investment
Prices used	Current prices	Current prices	Constant prices
Treatment of capital	Annual depreciation charge	Cash purchases and sales	Initial investment, residual value
Off-farm income	Excluded	Cash portion included	Cash and noncash included
Home-consumed farm production	Included	Excluded	Included
Performance criteria	Return to capital and labor engaged on farm	Cash available to farm family	Return to additional resources engaged
Time value	Undiscounted	Undiscounted	Discounted
Performance indicators	Profit as a percentage of net worth, family income	Cash surplus or deficit	Net present worth, internal rate of return, benefit-cost ratio, net benefit-investment ratio, net benefit increase

Source: Schaefer-Kehnert (1980).

a. Also called sources-and-uses-of-funds analysis.

b. Benefit-cost analysis of on-farm investments.

Preparing the Farm Investment Analysis

The starting point for both the financial and the economic analysis of an agricultural project is generally a group of investment analyses of pattern or model farms, based on budgets for individual pattern farms. These pattern farm budgets compare the situation with the project to that anticipated without the project for the duration of the project. They enable the analyst to form a sound judgment about the likely benefit to farmers of participating in an agricultural project and about the incentives for farmers to do so.

Farm investment analysis is the topic of this chapter. This analysis is similar to, and sometimes confused with, farm management analyses done by agricultural economists, which may be distinguished as farm income analysis and funds flow analysis. The differences are summarized in table 4-1.

Farm income analysis is generally used to evaluate the performance of a farm in a particular year. Its objective is to help improve the management of the farm. Current prices are used, and a depreciation allowance is included to account for that portion of longer-term capital investment used up in the year being considered. Noncash items such as home-consumed production and payments in kind are included. Off-farm income and expenditure are excluded because the analysis is intended to evaluate the performance only of the farm itself. The analysis provides an estimate of the return to capital invested and to the farmer's labor, and this may then be compared with the return to alternative cropping patterns or to off-farm opportunities.

Funds flow analysis, also called sources-and-uses-of-funds analysis, is used to determine a farmer's liquidity in an analysis of his credit situation. Only cash items, including purchase and sale of capital goods, enter the analysis. Off-farm cash income and expenditure are included, but home-consumed production is not. The analysis shows the cash available to the family over a period of time.

Farm investment analysis, in contrast, is undertaken to determine the attractiveness of a proposed investment to farmers and to other participants, including the society as a whole. It projects the effect on farm income of a particular investment and estimates the return to the capital engaged. It follows the principles of discounted cash flow analysis (discussed in detail in chapters 9 and 10). The analysis is projected over the useful life of the investment. The initial investment is shown at the beginning of the projection, and a residual value at the end. In general, the analysis is cast in constant prices, although allowance may have to be made for inflation. Off-farm income is included. Even though we use the term "cash flow," noncash elements enter the projection, including home-consumed production and payments and receipts in kind. (The term was first applied to industrial investments, in which noncash elements are less common.) When doing farm investment analysis, some

elements of funds flow analysis are often incorporated to enable the analyst to assess the farmer's liquidity and his credit use. Those who wish to pursue farm income analysis or funds flow analysis in relation to project analysis may refer to standard farm management texts such as Harsh, Connor, and Schwab (1981) and Kay (1981). Those who want more detail about the application of farm budgets to project analysis may consult Brown (1979).

Pattern farm investment analysis that includes farm budgets should be prepared for almost every agricultural project. Although agricultural project analyses that do not have farm budgets are used, it is increasingly accepted that farm budgets are an extremely desirable, if not essential, part of project analysis. The benefit stream of an agricultural project may be built up simply by multiplying the total area to be planted by the expected yield, essentially treating the whole area as one undifferentiated farm. If this is all that is done, it may hide crucial information about the effects of the project on individual farmers and obscure underlying unrealistic assumptions. Even when the project involves only a public sector undertaking, a farm budget is likely to be necessary to test the feasibility of the cropping pattern and the financial viability of the enterprise.

The purpose in preparing farm investment analyses for a project is not to take a sample of the farms in the project area. Rather, it is to select major farm types expected to participate and to look at the impact of the project on them. These farm investment analyses are usually projections for the life of the project, often twenty to twenty-five years, not for just a single year. The analyst will want to examine the cropping pattern and perhaps to diagram it; to determine the labor that will be required if farmers are to participate in the project and perhaps to prepare a month-by-month labor budget showing requirements and the availability of family labor; to look at production and inputs; and, finally, to prepare a farm budget in the detail needed for understanding and evaluating the effects of the project on the income of participating farmers. From these, the analyst can assess the financial effect of the proposed project on typical farms—both to judge incentives for participation and to determine whether national policies on minimum incomes for project participants are being met.

Farm investment analyses and farm budgets can of course be prepared for farms of any size. The problems of analyses for smaller farms are the focus here, since many, if not most, agricultural projects in developing countries will be directed toward smallholders whose families consume a large part of the food they produce.

Large commercial farms and plantations, however, whether publicly or privately held, are more like other business enterprises than they are like small, family-operated farms. Projected accounts for these large agricultural undertakings are probably more appropriately cast in formal financial statements such as those of the agricultural processing industries discussed in chapter 5.

In considering small farms, the analyst will be particularly concerned with the effect of the project on the total income of the farm family. The

aspects of the small farm as a family unit and as a business firm must be clearly understood and appreciated. These will differ from society to society, and the project analyst should either know the society well enough to anticipate the farmers' response or be advised by others who do. One must assess the attitude of the family to proposed cropping patterns that involve more days of labor, to patterns that increase cash crop output and reduce food crop production below household requirements, to patterns that change the work responsibilities of men and women, and to patterns that require the family to run a considerable market risk. Farmers *are* price responsive, of course; the extensive research has amply confirmed this (Krishna 1967). But farmers live in a particular cultural and risk environment, and project analysts must take this environment into account when they project their pattern farm investment analyses.

Backed by this understanding of the particular cultural environment, the analyst will prepare the farm investment analyses as realistically as possible to determine what the family gains by participating in the project. The projection must be based on a specific package of technological innovation. The effectiveness of the proposed new technology on small farms must be realistically assessed, and the technological assumptions must be checked to ensure that they reflect on-farm conditions and not those of an experiment station. The analyst must form a judgment about how rapidly farmers will be willing to adopt new practices. The farm investment analysis should confirm that adoption of a new technology will really be financially worthwhile, for farmers can respond to financial incentives only when it is truly remunerative for them to do so. The analyst must determine how much credit will stimulate farmers to adopt new practices and must assess how risky a new technology is and how variable the farm income may be under the project. The analyst will want to test the effect of risk on family income by determining what happens if yields fall below expectations or if prices are lower than anticipated and by undertaking similar sensitivity tests. Through such tests a margin to allow for bad years can be built into the farm plan.

Although in agricultural projects the analyst generally looks at budgets for entire farms, partial budgeting techniques can be used for undertakings that involve only a relatively minor change in the farm organization. To do this, one looks at the marginal cost (including opportunity cost) of adding a production activity and compares it with the marginal increase in benefit that the new activity will bring. Partial budgets are an effective tool for helping to search out the best combination of production activities. Brown (1979) discusses their use in some detail. In most projects, however, we expect rather substantial changes over a prolonged period, and under these circumstances it is better to project whole farm budgets. Then the total effect of the project on family income can be better assessed.

The information on which the project analyst will base his farm investment analysis will come from many sources. Project analysts will have to rely heavily on their professional colleagues to determine a sensible

cropping pattern and livestock activity for a proposed project, the output that may be expected, the inputs that will be required, and the relevant prices for products. The project analyst will want to pay particular attention to the realism of the estimates provided by the agriculturalists and livestock specialists he consults. Unrealistic assumptions about yields, input levels, or rates of farmer acceptance and, hence, of buildup in project benefits will negate the best of project analyses.

The analyst will certainly want to visit the site of the proposed project and typical farms that will be included. Nothing substitutes for the firsthand knowledge that being there brings.

A crucial source of information in every agricultural project is the farmers themselves. Only through interviews with farmers can a project analyst reach a valid conclusion about the realism of his farm investment analysis. The project analyst will want to interview farmers about their present cropping patterns, labor requirements, use of inputs, and the market prices actually received and paid. He will want to gain a sense about the farmers' willingness to participate in the project were it to proceed. In a project area or on a similar site some farmers often are already using a proposed new technology. It is most important that these farmers be interviewed to tap their experience. The analyst will want to know the yields the farmers actually have realized with the new technology, the inputs they actually must employ, and their general comments on the new technology and cropping pattern proposed for the project. The analyst will want to assess the labor requirements farmers have found necessary to use the new technology.

Interviewing farmers is an art in itself, and only a few comments can be made here. The information farmers give will usually be contradictory, but out of a group of interviews the project analyst can gain a sense of feasible technological and financial relations. Farmers will have to be interviewed in the field, not in the office. The analyst will have to know the local measurements and not expect everything to be reported neatly on a unit basis. The analyst or one of his staff should probably conduct the interviews alone or with very few other people around. Great care should be taken to establish a good atmosphere in the interview so that farmers are not overawed by the analyst's presence; farmers should also know that the information they give will not be used for tax purposes. A formal questionnaire may be helpful, especially if much information is to be collected by assistants, but any questionnaire should be carefully pretested in the field before use. It may be better for the analyst or his assistants to fill in the questionnaire only after the interview is complete and the interviewer has left the farmer. In any event, before the interviews the analyst should have formed a clear idea about the information he needs, perhaps in the form of a list of questions, so that critical information will not be overlooked. Questions put to farmers should be as specific as possible. Most information gathered should relate to actual experience, perhaps in the last cropping season. Questions about hypothetical situations should be avoided to the extent possible. The

very nature of seeking information about a proposed project will, however, of necessity involve many "what if" kinds of questions.

Cropping patterns are usually based on the judgment of the agriculturalists and livestock specialists working with the project analyst. Their judgment, in turn, will be based on their familiarity with the agriculture of the area, on research results and the results of pilot projects—perhaps undertaken especially as part of the project preparation—and on their knowledge of the farmers who will participate in the project. In most instances, experienced technicians can propose realistic patterns close to the optimum, but sometimes linear programming may be used as a more formal methodology to optimize cropping patterns. Linear programming has been applied in preparing agricultural project analyses but is not regularly used either in national planning agencies or in international lending agencies. It is a complex methodology that requires more formal input-output data than does simple budgeting, and in practice it requires computers. There are serious methodological limitations to the use of linear programming for agricultural project analysis: problems of dealing with risk, farmers' cultural traditions, variability of soils within farms, water availability in different areas of a farm, and other farm-level variations. Even so, when preparing a project for an area where there is inadequate experience to rely on in forming subjectively determined cropping patterns or when dealing with very complex patterns, the project analyst may want to consult specialists in linear programming for assistance. In these cases, the project preparation takes on some of the character of a research effort. Because it is a well-known methodology widely used in farm management research, many agricultural colleges have staff familiar with linear programming.

In most agricultural projects, about half a dozen or so pattern farm investment analyses will suffice, but generalization about this is dangerous. The number of pattern farm analyses depends entirely on the complexity of the project. The analyst will want a pattern farm investment analysis for each major group of soil and water conditions in the project area and for each major difference in the size of holdings. Of course, each major cropping pattern or livestock activity will require a separate farm investment analysis. Remember that the objective is an indication of the effect of the project, not some kind of rigorously drawn, random sample. In practice, the number of farm budgets prepared for any given project analysis is a tradeoff between the complexity of the proposed project and the availability of staff to prepare the investment analyses.

Each farm investment analysis will be the result of careful consultation with technical specialists and interviews with farmers. Just as it is not possible to generalize about how many pattern farm budgets will be necessary, neither is it possible to generalize about how many interviews with farmers will be needed. Thorough preparation of a complex project may require twenty-five to fifty or even more interviews to provide the information for each farm analysis. But a simpler project that will use a better-known technology may require only half a dozen to a dozen inter-

views for each pattern farm budget. A group doing an appraisal of a proposed project would probably interview fewer farmers than was necessary in the initial project preparation. Each situation will have to be judged by itself in the light of how confident the analyst needs to be about the project analysis, how complex the project is, how well known the technology is, and how available are staff for project preparation.

Similar considerations apply in deciding the level of detail necessary in a farm investment analysis. Any farm investment analysis is intended to improve the decisionmaking for a project. It is, of necessity, an abstraction. This imprecision is forced on us by the very fact that we must predict future events, but it also arises from the question of just how much detail is necessary. In every farm investment analysis, the project analyst will reach a point at which further elaboration or further detail would make such a marginal contribution to the investment decision that it is not worth the time. Just when that point is reached will vary from project to project according to the circumstances of the project and the circumstances of the decisionmaking process.

It is easy to conceive of a set of pattern farm investment analyses that would be so enormously detailed and have so many different budgets that the process would quickly become bogged down in detail. Because of staff limitations and because of the approximate nature of the underlying data, it is better to hold both the number of pattern farms and the level of detail to the minimum that will serve to lay out clearly the major points about the project.

The project analyst will have to determine how best to present his information so that those who must review his work and make decisions about the project can work efficiently and yet have the information they need. The major entries, the level of detail, and the like will vary from project to project. Some of the elements given in separate tables in the illustrative examples in this chapter may be better combined in the tables that present a particular project. In many project reports, only a summary of background information, plus a detailed farm budget, will be needed. Other, more detailed tables can be included in annexes or in a separate volume of background information reproduced in limited quantities and circulated only to those most interested in the project. This kind of additional data can even be kept in a separate project information file that can be made available to anyone seriously interested. (In the Paraguay report used as an example in this chapter, the analyst presented his farm investment analysis in four annex tables and collected the supporting information in a separate project information file.)

What we will present here is a pattern format that includes the features most commonly of significance in agricultural project analysis. This pattern format uses a terminology generally accepted by both farm management specialists and accountants. In using the format, the analyst will have to determine for himself, for each project in his charge, exactly how much detail is necessary to support the analysis and exactly how this detail is best reported to facilitate decisions about the particular project.

Elements of Farm Investment Analysis

The principal elements of farm investment analysis are outlined in this subsection and are listed in table 4-2. A flow chart for preparing the analysis is given in figure 4-1. Not every element will be necessary in every analysis, and the means of presenting the elements will vary from project to project according to circumstances.

The most important elements of a farm investment analysis can be illustrated by an example adapted from the Paraguay Livestock and Agricultural Development Project. (Tables that illustrate particular elements of the analysis are noted in table 4-2.) The project is to increase agricultural production, productivity, and income on some 940 livestock farms and some 3,000 mixed farms, mostly small, through on-farm investments supported by credit, technical assistance, feeder roads, and market improvement. Most of the important aspects of preparing a farm investment analysis are touched on in this example, but it is clear that no single example can cover every possibility. Each project analyst will want to build on the illustrative tables that outline this one example for the purposes of his own project analysis. As in all accounts, the objectives of the farm investment account determine its content and format.

Accounting convention for farm investment analysis

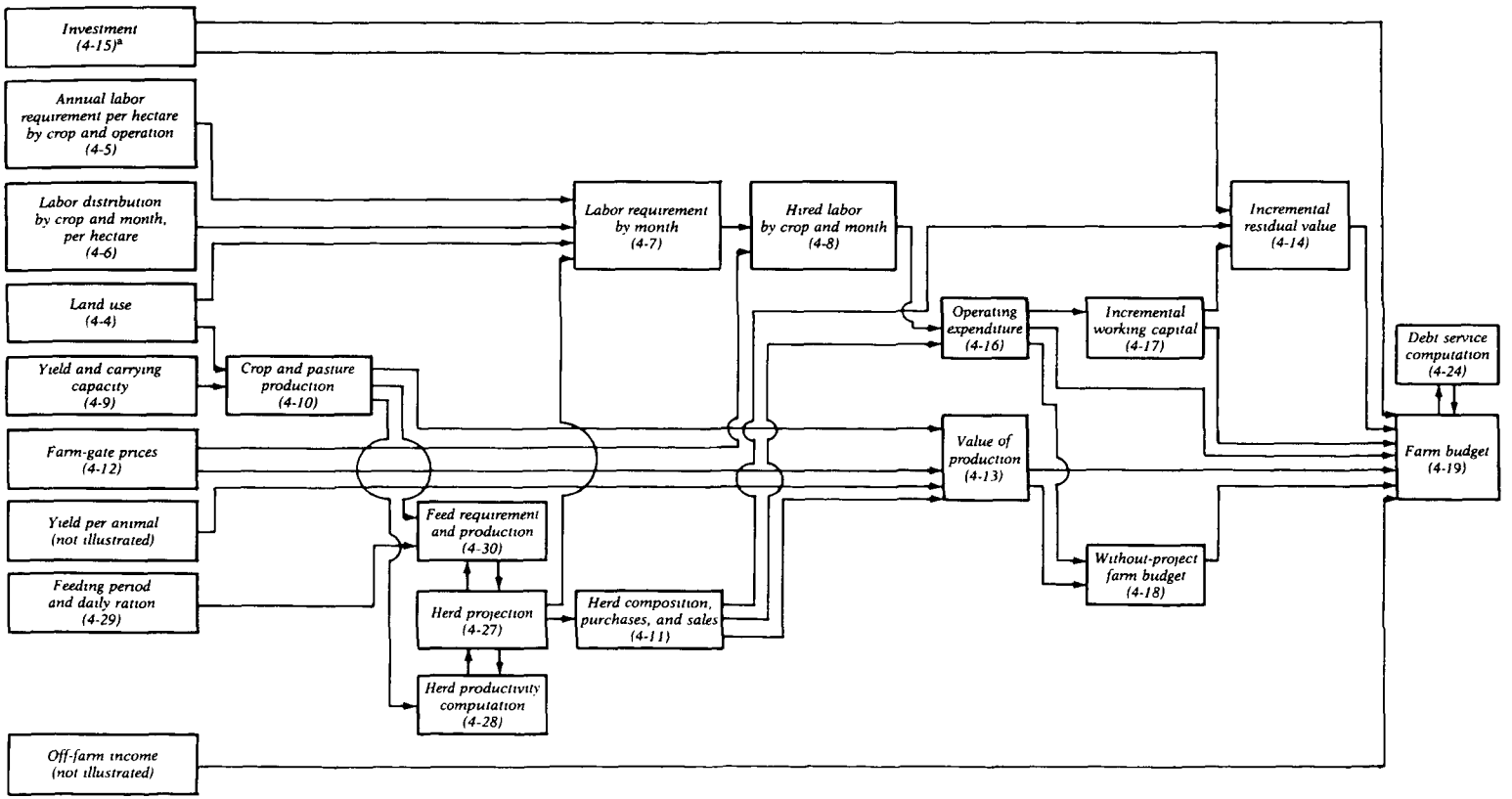
Because farm investment analysis follows the principles of discounted cash flow, it is convenient to adopt an accounting convention that is congruent with those principles. [This convention has been called "time-adjusted" by Schaefer-Kehnert (1980), who has elaborated its use.] The discounting process used in discounted cash flow analysis implicitly assumes that every transaction falls at the end of the accounting period. It is desirable that the farm investment analysis match this assumption. This is simply accomplished if we consider the initial investment to take place at the end of year 1 of the project, regardless of whether it will actually take a full year or only a few weeks. Year 2, then, is the first accounting period in which increases in operating cost and incremental benefits occur. Thus, the dividing line between the end of the initial investment period and the beginning of the incremental production operations coincides exactly with the dividing line between years 1 and 2 of the project. (Some analysts accomplish much the same result by considering investment to fall in year 0, but this gives rise to problems when cash flows are aggregated.) Considering that preparing a farm plan, making a loan, constructing or purchasing investment items, and purchasing new inputs can take at least several months to a year, reserving year 1 for investment is not unrealistic. Doing so, however, is not dictated by real events but by the accounting convention.

If all transactions are considered to fall at the end of the accounting period, then we must allow for the availability of the needed operating

Table 4-2. *Principal Elements of Farm Investment Analysis*

Element	*Illustrative table*
Farm resource use	
Land use	4-4
(Land use calendar)	(Figure 4-2)
Labor use	
Annual labor requirement by crop operation, by crop for 1 hectare	4-5
Labor distribution by crop and month, per hectare	4-6
(Labor use diagram)	(Figure 4-3)
Labor requirement by crop and month	4-7
Hired labor by crop and month	4-8
Off-farm labor	Not illustrated
Farm production	
Crops and pasture	
Yield and carrying capacity	4-9
Crop and pasture production	4-10
Livestock	
Herd projection	4-27
Herd composition, purchases, sales	4-11
Herd productivity	4-28
Feeding period and daily ration	4-29
Feed requirement and production	4-30
Yield per animal	Not illustrated
Valuation	
Farm-gate prices	4-12
Value of production	
Crops	4-13
Livestock	
Incremental residual value	4-14
Farm inputs	
Investment	
Physical	4-15
Foreign exchange component	Not illustrated
Value of investment	4-15
Operating expenditure	
Crop	4-16
Livestock	
Incremental working capital	4-17
Farm budget	
Without project	4-18
With project	
Net benefit before financing	4-19
Debt service	4-24
Net benefit after financing	4-19
Cash position	

Figure 4-1. *Flow Chart for Farm Investment Analysis*



a. Numbers in parentheses refer to the illustrative tables in this chapter.

expenditure at the beginning of the cropping season. This is accomplished by incorporating in the analysis an entry for incremental working capital at the end of the preceding year. The amount of the working capital needed is related to the farming system being analyzed. If a single annual crop is produced, then nearly all the operating expenditure will be needed at the beginning of the crop year. But if two crops are to be produced in succession, only the operating expenditure for the first crop need be on hand at the beginning of the crop year, since there will be a harvest during the year that will provide proceeds to replace the input supplies needed before the second crop is harvested. Thus, only half the total annual operating expenditure need be on hand at the beginning of the year. The *incremental* working capital needed (either an increase or a decrease) at the beginning of the year, then, is entered at the end of the year *preceding* the year when it will be expended for production. A set of recommended adjustments in incremental operating expenditure to obtain incremental working capital is given in table 4-3. Introducing an incremental working capital stream reflects real resource use. When an investment is undertaken, short-term inputs such as seed, fertilizer, feed, and the like must be on hand. They are replaced from the proceeds of the harvest or livestock sales during the year and are again on hand for production in the following year. If operations are to expand the next year, then stocks of inputs for production must be increased, and this will be reflected in another incremental working capital entry. Since the incremental working capital is entered separately, it will easily be included in the total investment shown when the farm budget is prepared and will not be inadvertently overlooked. At the end of the project, the incremental working capital for each year is added together algebraically and taken out of the project as part of the residual value. Thus, including incremental working capital in the accounts does not result in double counting.

One practical outcome of this accounting convention is that operating expenditures and benefits in year 1 generally remain the same as they were without the project. In some cases new investment might require an increase in operating expenditure in year 1, even though production

Table 4-3. *Incremental Working Capital as a Percentage of Incremental Operating Expenditure*

Item	*Percent*
Tree crops (slowly maturing, one harvest season)	100
Annual crops	
One season	80–100
Two seasons	40–60
Continuous cropping and continuously producing livestock enterprises	20–40

Source: Schaefer-Kehnert (1980).

would not be affected until year 2. In other instances, both operating expenditures and production might actually decrease—as might happen if new irrigation canals were to be constructed, disrupting farming operations. In laying out the farm investment analysis, however, it is usually considered that working capital is not freed as a result of the investment so that the layout of the farm budget can be simplified. If this were not done, both data for the case without the project and data for a "preproject" year or "year 1" would be needed to accommodate the decision rule that working capital be a proportion of the increase or decrease in the operating expenditure for the following year.

Showing working capital as a separate entry facilitates determining how much short-term credit may be needed by the farmer. A judgment may be made about whether the farmer will have savings from which to finance increased working capital or whether some proportion or all will have to be covered by extending the farmer a short-term loan, which then can be incorporated into the financing section of the farm budget.

The accounting convention adopted here is not much different from that most commonly used by project analysts. The most important difference is the rule of reserving year 1 for investment only and assuming the investment to fall at the end of the year. It is more common to include investment in year 1 but to assume that it will occur at the *beginning* of the year, even though the discounting process assumes it falls at the end of the year. Production is then assumed to be increased in year 1, an assumption that leads to an overestimate of the rate of return on the capital used. It also leads to a considerable overestimate of the farmer's income in the early years of the project and, hence, to an underestimate of his need for both long-term and short-term credit. The other difference between the accounting convention adopted here and that most commonly used by project analysts is only a matter of completeness. It is easy inadvertently to omit or underestimate working capital unless such capital is included in the convention. This convention for working capital leaves the crop year intact and therefore facilitates the supporting technical projections.

Farm resource use

Once the agronomists, livestock technicians, and other technical specialists have determined the components of a proposed farming system for a pattern farm, the analyst may proceed to prepare the farm investment analysis.

LAND USE. The first step is to determine what the land use on the farm will be. The land use for the Paraguay project is given in table 4-4. Note that the crop year is taken to extend from July of one calendar year to June of the next, since this arrangement makes the break in the year come during the Paraguayan winter season, when there are the fewest crops in the ground. The total farm area is 20.0 hectares, divided into *cultivated area, pasture, forest,* and a *house plot.* (Throughout the text of this chapter,

Table 4-4. *Land Use, 20-Hectare Mixed Farm, Livestock and Agricultural Development Project Model IV, Paraguay*
(hectares)

Type of use and crop[a]	*Without project*	*With project*					
		Year 1	*2*	*3*	*4*	*5*	*6–20*
Cultivated area							
Maize[b]	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Manioc[b]	1.0	1.0	1.0	1.0	0.5	0.5	0.5
Beans	0.5	0.5	0.5	0.5	0.5	0.5	0.0
Cotton	2.0	2.0	2.0	2.0	2.2	2.5	3.0
Soybeans	0.0	0.0	1.0	1.0	2.2	2.5	3.0
Sunflower[c]	0 0	0.0	2 0	2.0	2.2	2.5	3.0
Total	4.0	4.0	7.0	7.0	8.1	9.0	10.0
Total cropland[d]	4.0	4.0	5.0	5.0	5.9	6.5	7.0
Cropping intensity[e]	1 0	1.0	1.4	1.4	1 4	1.4	1.4
Pasture							
Natural	10.5	7 0	3 5	0.0	0.0	0.0	0 0
Improved	0.0	3.5	7.0	10.5	10.5	10.5	10.5
Total	10.5	10.5	10 5	10.5	10.5	10.5	10.5
Forest	5.0	5.0	4.0	4.0	3.1	2.5	2.0
House plot	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total farm area	20 0	20.0	20 0	20.0	20.0	20.0	20.0

Source: Adapted from World Bank, "Staff Appraisal Report: Paraguay—Livestock and Agricultural Development Project," 2272–PA (Washington, D.C., 1979; restricted circulation), annex 1, table 17.

a. Operated by one family with six members and a work potential of 70 work days a month. A work day is the time (generally eight hours) devoted by one person during one day.

b. Maize and manioc are intercropped.

c. Double-cropped after cotton or soybeans. The area given is the area planted in the year shown.

d. Does not include second crop area, in this case the area planted in sunflower.

e. Cropping intensity is determined by dividing the total cultivated area by the total cropland.

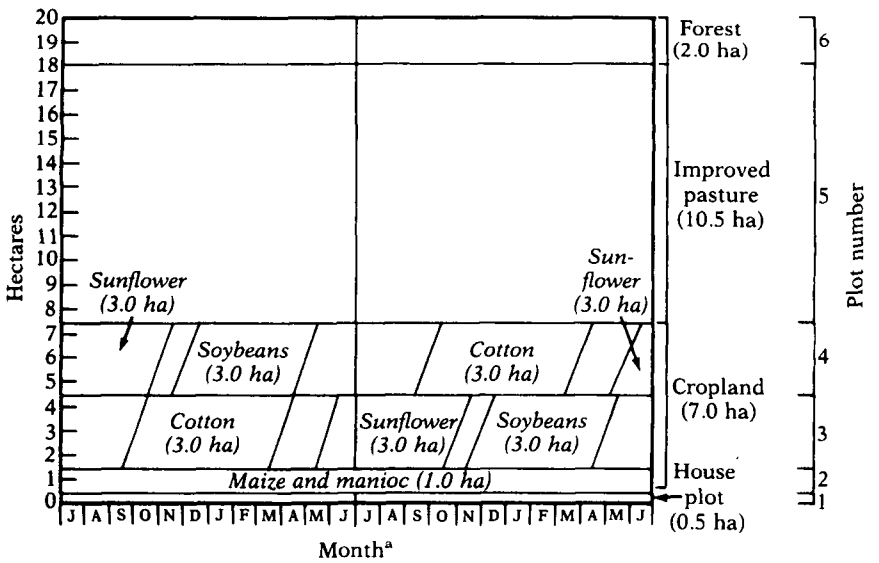
the most common or generalized categories from the pattern tables will be shown in *italic* type. These items would be considered in any farm investment analysis. In all tables the generalized analytical framework applies, but in some the categories are all specific to the project analyzed.)

The land use, in accord with the accounting convention adopted, would remain unchanged in year 1, except for establishment of improved pasture that is part of the investment. In year 2, in which the proposed cropping pattern calls for sunflower to be introduced and to be double-cropped after either cotton or soybeans (depending on the year), both the total cultivated area and the total *cropland* are shown. The total cultivated area is the total area planted in crops, whereas the total cropland is the area available to cultivate. When the total cultivated area is divided by the total cropland, the *cropping intensity* is obtained. In year 2, for

example, the cropping intensity is 1.4 (7.0 ÷ 5.0 = 1.4). Many analysts prefer to report cropping intensity in percentages, so this would be reported as 140 percent. One check of the feasibility of the cropping pattern is the intensity. The analyst should be cautious about accepting a cropping pattern that has a very high cropping intensity or one that is markedly different from the pattern existing in the area. Farmers may well have good reasons for not driving up the intensity.

Many analysts also like to devise a cropping diagram, such as that given in figure 4-2, and this should be subdivided to indicate any existing farm plots. Such a diagram is usually drawn up only for the full-development situation. The diagram indicates the area to be devoted to each category of land use and each crop. In the case of our example, it extends over two years to show that the seasonal timing of the cotton-sunflower-soybean rotation occurs on one plot in one year and on another in the next. Checking vertically at any one time, we can be sure the cropping pattern does not call for more area than the farm has. Checking horizontally, we can determine when each crop must be planted and whether enough land will be available at the proper season. The left and right sides of the boxes showing the area to be planted in each crop are slanted to indicate the planting and harvest time necessary for each crop. Examining the cropping diagram can help determine if there will be adequate time between crops to prepare the land.

Figure 4-2. *Land Use Calendar for Project Years 6–20, 20-Hectare Mixed Farm, Livestock and Agricultural Development Project, Paraguay*



ha Hectares.
Source: Table 4-4.
a. Crop year is from July to June.

LABOR USE. A second aspect of the farm resource use is labor. To determine the labor the farm will require, we need to know the labor used to cultivate a hectare of each crop in each project year. It is desirable to be able to see this in two forms, by operation and by month. Table 4-5 shows the annual labor requirements for 1 hectare by crop and operation for the Paraguay project example. It includes the labor required not only for the various crops to be produced, but also for the pasture. The labor unit is a work day, the time (generally eight hours) devoted by one person during one day. The labor requirement for crops drops sharply between years 1 and 2 because of the introduction of draft animal power. In the case of pasture, the labor requirement for fencing and seeding is included in years 1 through 3. In the Paraguay model, other activities of pasture establishment are to be undertaken by a contractor, so there will be no call for labor from the farmer. If, however, labor for establishing some other kind of improvement were expected, such as farmers' digging their own tertiary canals in an irrigation project, then this should be included in the labor requirement.

Table 4-5. *Annual Labor Requirement per Hectare by Crop and Operation, 20-Hectare Mixed Farm, Paraguay Project*
(work days)

Crop and operation	Without project	With project						
		Year 1	*2*	*3*	*4*	*5*	*6*	*7–20*
Crops								
Maize								
Land preparation and planting	22	22	11	11	11	11	11	11
Cultivation[a]	9	9	2	2	2	2	2	2
Harvesting	28	28	28	31	31	33	33	36
Total	59	59	41	44	44	46	46	49
Manioc								
Land preparation and planting	14	14	10	10	10	10	10	10
Cultivation[a]	27	27	15	15	15	15	15	15
Harvesting	19	19	19	21	21	23	23	25
Total	60	60	44	46	46	48	48	50
Beans								
Land preparation and planting	24	24	19	19	19	19	19	19
Cultivation	10	10	4	4	4	4	4	4
Harvesting	20	20	20	22	22	22	22	22
Total	54	54	43	45	45	45	45	45
Cotton								
Clearing	18	18	8	8	8	8	8	8
Plowing			3	3	3	3	3	3
Harrowing (2 times)			2	2	2	2	2	2
Seeding	4	4	1	1	1	1	1	1
Thinning	6	6	6	6	6	6	6	6
Cultivation (3 times)	30	30	3	3	3	3	3	3
Spraying (5 times)	10	10	10	10	10	10	10	10
Harvesting	37	37	43	43	46	46	49	49
Drying, packing, marketing	4	4	4	4	4	4	4	4
Total	109	109	80	80	83	83	86	86

Table 4-5 (*continued*)

Crop and operation	Without project	With project						
		Year 1	2	3	4	5	6	7–20
Soybeans								
Clearing	—	—	8	8	8	8	8	8
Plowing	—	—	3	3	3	3	3	3
Harrowing (2 times)	—	—	2	2	2	2	2	2
Seeding	—	—	1	1	1	1	1	1
Thinning	—	—	6	6	6	6	6	6
Cultivation (2 times)	—	—	2	2	2	2	2	2
Spraying (2 times)	—	—	4	4	4	4	4	4
Harvesting	—	—	18	18	20	20	22	22
Transport	—	—	3	3	3	3	4	4
Total	—	—	47	47	49	49	52	52
Sunflower								
Clearing	—	—	6	6	6	6	6	6
Plowing	—	—	3	3	3	3	3	3
Harrowing (2 times)	—	—	2	2	2	2	2	2
Sowing	—	—	1	1	1	1	1	1
Thinning	—	—	6	6	6	6	6	6
Cultivation (2 times)	—	—	2	2	2	2	2	2
Spraying (2 times)	—	—	4	4	4	4	4	4
Harvesting	—	—	13	14	14	15	15	15
Drying, packing, marketing	—	—	4	4	4	5	5	5
Total	—	—	41	42	42	44	44	44
Pasture								
Improved establishment								
Fencing	—	7	7	7	0	0	0	0
Seeding	—	2	2	2	0	0	0	0
Maintenance	—	—	3	3	3	3	3	3

Note: For the area in various crops, see table 4-4.

Source: Adapted from A. O. Ballantyne, "Paraguay—Small Farmer Credit Component, Livestock and Agricultural Development Project," working papers on file (Washington, D.C.: World Bank, 1978; restricted circulation).

a. Maize and manioc are intercropped. Hence, during the period when both are growing, the allocation of cultivation time between the two crops has an arbitrary element.

The total labor requirement per hectare for each crop is distributed by month in table 4-6. The monthly distribution is most important because we must determine not only the total annual labor requirement on the farm but also its timing to assess whether sufficient family labor will be available and, if there is not enough, how much hired labor will be needed. Although some farm management analysts break down the labor requirement by week or fortnight, for purposes of project analysis the monthly distribution is sufficient.

On a mixed farm, livestock will also require labor. This may be calculated by determining how much time will be needed per animal unit in the livestock herd. An animal unit is a measurement of feed demand by a particular class of animal. (This is discussed in more detail in the appendix to this chapter. The total animal units for each year are reported in table 4-11. They are given in that table for the livestock herd that could exist on 100 model farms to avoid the problem of divisibility that arises

when the increase in large livestock on a small farm is projected. Thus, to obtain the animal units on one farm, the total reported in table 4-11 must be divided by 100. We will return to a discussion of this convention in the next subsection, when we discuss the herd composition.) In the Paraguay example, it is assumed that each animal unit will require five minutes of care a day and that the requirement will be the same each month throughout the year. The labor requirement is determined on the basis of the animal units at the beginning of the year. Using animal units rather

Table 4-6. *Labor Distribution by Crop and Month, 20-Hectare Mixed Farm, Paraguay Project*
(work days per hectare)

Crop	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Total*
Maize[a]													
Without project, year 1	14	8	0	5	4	28	0	0	0	0	0	0	59
Year 2	9	2	0	1	1	28	0	0	0	0	0	0	41
Years 3–4	9	2	0	1	1	31	0	0	0	0	0	0	44
Years 5–6	9	2	0	1	1	33	0	0	0	0	0	0	46
Years 7–20	9	2	0	1	1	36	0	0	0	0	0	0	49
Manioc[a]													
Without project, year 1	0	0	14	3	3	3	4	3	5	3	3	19	60
Year 2	0	0	10	2	2	1	2	2	2	2	2	19	44
Years 3–4	0	0	10	2	2	1	2	2	2	2	2	21	46
Years 5–6	0	0	10	2	2	1	2	2	2	2	2	23	48
Years 7–20	0	0	10	2	2	1	2	2	2	2	2	25	50
Beans													
Without project, year 1	0	0	0	0	24	5	5	20	0	0	0	0	54
Year 2	0	0	0	0	19	2	2	20	0	0	0	0	43
Years 3–5	0	0	0	0	19	2	2	22	0	0	0	0	45
Cotton													
Without project, year 1	0	0	8	14	8	19	19	7	20	14	0	0	109
Years 2–3	0	0	8	6	8	6	5	8	25	14	0	0	80
Years 4–5	0	0	8	6	8	6	5	8	27	15	0	0	83
Years 6–20	0	0	8	6	8	6	5	9	28	16	0	0	86
Soybeans													
Years 2–3	0	0	0	0	13	8	3	2	10	8	3	0	47
Years 4–5	0	0	0	0	13	8	3	2	10	10	3	0	49
Years 6–20	0	0	0	0	13	8	3	2	11	11	4	0	52
Sunflower[b]													
Year 2	2	9	3	13	4	0	0	0	0	0	6	4	41
Years 3–4	2	9	3	14	4	0	0	0	0	0	6	4	42
Years 5–20	2	9	3	15	5	0	0	0	0	0	6	4	44
Pasture													
Improved establishment													
Fencing	2	5	0	0	0	0	0	0	0	0	0	0	7
Seeding	0	0	0	0	2	0	0	0	0	0	0	0	2
Maintenance	0	0	0	0	0	0	0	1	0	0	1	1	3

Note: Same as table 4-5.
Source: Same as table 4-5.
a. See note a, table 4-5.
b. Labor requirements for sunflower apply to the year of planting. Thus, in year 2 the labor requirement is for the crop planted in May of year 2 and harvested in October of year 3.

than each individual class of animal as the basis for estimating the labor requirement considerably simplifies the computation and is not unrealistic. In the convention recommended here, for example, closing livestock figures do not include heifers two to three years old or steers sold during the year, in this case steers three to four years old. Opening livestock figures, however, omit calves. In reality, closing and opening figures tend to balance each other, since heifers will be transferred to the breeding herd throughout the year and surplus heifers and steers will be sold throughout the year, whereas calves will be born throughout the year. Attempting a more precise estimate would only lead to superficial precision because the error in estimating the daily requirement for labor considerably exceeds any gain in accuracy.

Having determined the labor requirement for each crop or animal unit by month, we proceed to calculate the labor requirement for the pattern farm. This is given for the Paraguay example in table 4-7. Here the labor required for each crop during each project year is given. The total by month and the amount to be provided by *family labor* and by *hired labor* are determined. In the Paraguay example, it is assumed that the family on the pattern farm will have available 70 work days of labor a month and that any labor requirement in excess of this amount will be supplied by hired labor. This is a very mechanistic assumption, of course. Not only will families vary widely in the labor they have available—even on farms of quite comparable size and cropping pattern—but families will also tend to work longer hours in busy seasons and rest in the off-season. For purposes of the farm investment analysis, however, this approximation is quite sufficient, given the wide margin of error in the estimates of the labor requirement in general. In the Paraguay example, table 4-7 shows that hired labor will be needed on the farm from year 4 onward. By year 7, in the peak month of March, about 44 percent of the total labor required for cotton and soybeans will have to be hired.

When a labor budget shows a need for hired labor, as this example does, the project analyst must consider carefully whether the labor will be available in the project area. Totaling the hired labor requirement for the project as a whole is one of the real advantages of including the labor budget in the farm investment analysis, since the analyst must then consider the realism of the proposed pattern in light of the added hired labor that can reasonably be expected to be available in the project area. Postulating 56 additional work days of hired labor in March is one thing; whether such additional labor would be available for an entire proposed project is another. It may be that a proposed cropping pattern will prove unrealistic in its requirements of additional hired labor, and a less labor-intensive cropping pattern must be proposed. Furthermore, if the project will call for substantial amounts of additional hired labor in relation to the supply available in the region, this may have implications about the sources from which the labor must be drawn and, hence, about the opportunity cost of the hired labor. In turn, this opportunity cost will have to be considered when making the estimates of the economic value of the labor (see chapter 7).

Table 4-7. *Labor Requirement by Crop and Month, 20-Hectare Mixed Farm, Paraguay Project*
(work days)

Year and crop or activity	*Unit*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Total*
Without project														
Maize	0.5 ha	7	4	0	2	2	14	0	0	0	0	0	0	29
Manioc	1.0 ha	0	0	14	3	3	3	4	3	5	3	3	19	60
Beans	0.5 ha	0	0	0	0	12	2	2	10	0	0	0	0	26
Cotton	2.0 ha	0	0	16	28	16	38	38	14	40	28	0	0	218
Livestock[a]	13.6 a.u.	4	4	4	4	4	4	4	4	4	4	4	4	48
Total		11	8	34	37	37	61	48	31	49	35	7	23	381
Family labor[b]		11	8	34	37	37	61	48	31	49	35	7	23	381
Hired labor		0	0	0	0	0	0	0	0	0	0	0	0	0
Year 1														
Maize	0.5 ha	7	4	0	2	2	14	0	0	0	0	0	0	29
Manioc	1.0 ha	0	0	14	3	3	3	4	3	5	3	3	19	60
Beans	0.5 ha	0	0	0	0	12	2	2	10	0	0	0	0	26
Cotton	2.0 ha	0	0	16	28	16	38	38	14	40	28	0	0	218
Livestock	13.6 a.u.	4	4	4	4	4	4	4	4	4	4	4	4	48
Improved pasture														
Fencing and seeding	3.5 ha	7	18	0	0	7	0	0	0	0	0	0	0	32
Total		18	26	34	37	44	61	48	31	49	35	7	23	413
Family labor		18	26	34	37	44	61	48	31	49	35	7	23	413
Hired labor		0	0	0	0	0	0	0	0	0	0	0	0	0

Year 2														
Maize	0.5 ha	4	1	0	0	0	14	0	0	0	0	0	0	19
Manioc	1.0 ha	0	0	10	2	2	1	2	2	2	2	2	19	44
Beans	0.5 ha	0	0	0	0	10	1	1	10	0	0	0	0	22
Cotton	2.0 ha	0	0	16	12	16	12	10	16	50	28	0	0	160
Soybeans	1.0 ha	0	0	0	0	13	8	3	2	10	8	3	0	47
Sunflower[c]	2.0 ha	0	0	0	0	0	0	0	0	0	0	12	8	20
Livestock	17.2 a.u.	5	5	5	5	5	5	5	5	5	5	5	5	60
Improved pasture														
Fencing and seeding	3.5 ha	7	18	0	0	7	0	0	0	0	0	0	0	32
Maintenance[d]	3.5 ha	0	0	0	0	0	0	0	4	0	0	4	4	12
Total		16	24	31	19	53	41	21	39	67	43	26	36	416
Family labor		16	24	31	19	53	41	21	39	67	43	26	36	416
Hired labor		0	0	0	0	0	0	0	0	0	0	0	0	0
Year 3														
Maize	0.5 ha	4	1	0	0	0	16	0	0	0	0	0	0	21
Manioc	1.0 ha	0	0	10	2	2	1	2	2	2	2	2	21	46
Beans	0.5 ha	0	0	0	0	10	1	1	11	0	0	0	0	23
Cotton	2.0 ha	0	0	16	12	16	12	10	16	50	28	0	0	160
Soybeans	1.0 ha	0	0	0	0	13	8	3	2	10	8	3	0	47
Sunflower	2.0 ha	4	18	6	26	8	0	0	0	0	0	12	8	82
Livestock	19.9 a.u.	6	6	6	6	6	6	6	6	6	6	6	6	72
Improved pasture														
Fencing and seeding	3.5 ha	7	18	0	0	7	0	0	0	0	0	0	0	32
Maintenance	7.0 ha	0	0	0	0	0	0	0	7	0	0	7	7	21
Total		21	43	38	46	62	44	22	44	68	44	30	42	504
Family labor		21	43	38	46	62	44	22	44	68	44	30	42	504
Hired labor		0	0	0	0	0	0	0	0	0	0	0	0	0

(Table continues on following pages.)

Table 4-7 (*continued*)

Year and crop or activity	*Unit*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Total*
Year 4														
Maize	0.5 ha	4	1	0	0	0	16	0	0	0	0	0	0	21
Manioc	0.5 ha	0	0	5	1	1	0	1	1	1	1	1	10	22
Beans	0.5 ha	0	0	0	0	10	1	1	11	0	0	0	0	23
Cotton	2.2 ha	0	0	18	13	18	13	11	18	59	33	0	0	183
Soybeans	2.2 ha	0	0	0	0	29	18	7	4	22	22	7	0	109
Sunflower	2.2 ha	4	18	6	28	8	0	0	0	0	0	13	9	86
Livestock	22.7 a.u.	7	7	7	7	7	7	7	7	7	7	7	7	84
Improved pasture														
Maintenance	10.5 ha	0	0	0	0	0	0	0	10	0	0	10	10	30
Total		15	26	36	49	73	55	27	51	89	63	38	36	558
Family labor		15	26	36	49	70	55	27	51	70	63	38	36	536
Hired labor		0	0	0	0	3	0	0	0	19	0	0	0	22
Year 5														
Maize	0.5 ha	4	1	0	0	0	16	0	0	0	0	0	0	21
Manioc	0.5 ha	0	0	5	1	1	0	1	1	1	1	1	12	24
Beans	0.5 ha	0	0	0	0	10	1	1	11	0	0	0	0	23
Cotton	2.5 ha	0	0	20	15	20	15	12	20	68	38	0	0	208
Soybeans	2.5 ha	0	0	0	0	32	20	8	5	25	25	8	0	123
Sunflower	2.5 ha	4	20	7	31	9	0	0	0	0	0	15	10	96
Livestock	24.6 a.u.	8	8	8	8	8	8	8	8	8	8	8	8	96
Improved pasture														
Maintenance	10.5 ha	0	0	0	0	0	0	0	10	0	0	10	10	30
Total		16	29	40	55	80	60	30	55	102	72	42	40	621
Family labor		16	29	40	55	70	60	30	55	70	70	42	40	577
Hired labor		0	0	0	0	10	0	0	0	32	2	0	0	44

Year 6														
Maize	0.5 ha	4	1	0	0	0	16	0	0	0	0	0	0	21
Manioc	0.5 ha	0	0	5	1	1	0	1	1	1	1	1	12	24
Cotton	3.0 ha	0	0	24	18	24	18	15	27	84	48	0	0	258
Soybeans	3.0 ha	0	0	0	0	39	24	9	6	33	33	12	0	156
Sunflower	3.0 ha	5	22	8	38	12	0	0	0	0	0	18	12	115
Livestock	25.1 a.u.	8	8	8	8	8	8	8	8	8	8	8	8	96
Improved pasture														
Maintenance	10.5 ha	0	0	0	0	0	0	0	10	0	0	10	10	30
Total		17	31	45	65	84	66	33	52	126	90	49	42	700
Family labor		17	31	45	65	70	66	33	52	70	70	49	42	610
Hired labor		0	0	0	0	14	0	0	0	56	20	0	0	90
Years 7–20														
Maize	0.5 ha	4	1	0	0	0	18	0	0	0	0	0	0	23
Manioc	0.5 ha	0	0	5	1	1	0	1	1	1	1	1	12	24
Cotton	3.0 ha	0	0	24	18	24	18	15	27	84	48	0	0	258
Soybeans	3.0 ha	0	0	0	0	39	24	9	6	33	33	12	0	156
Sunflower	3.0 ha	6	27	9	45	15	0	0	0	0	0	18	12	132
Livestock	25.0 a.u.	8	8	8	8	8	8	8	8	8	8	8	8	96
Improved pasture														
Maintenance	10.5 ha	0	0	0	0	0	0	0	10	0	0	10	10	30
Total		18	36	46	72	87	68	33	52	126	90	49	42	719
Family labor		18	36	46	70	70	68	33	52	70	70	49	42	624
Hired labor		0	0	0	2	17	0	0	0	56	20	0	0	95

ha Hectares; a.u. animal units.

Source: Calculated from tables 4-4 and 4-6.

a. Assumes five minutes a day per animal unit, eight hours a day, and thirty days a month. The labor requirement is based on the animal units at the beginning of the year (as given in table 4-11) divided by 100 to give the labor requirement for a single farm. See text (the subsection "Farm production. Livestock") for a discussion of this convention.

b. Assumes 70 work days per month of available family labor.

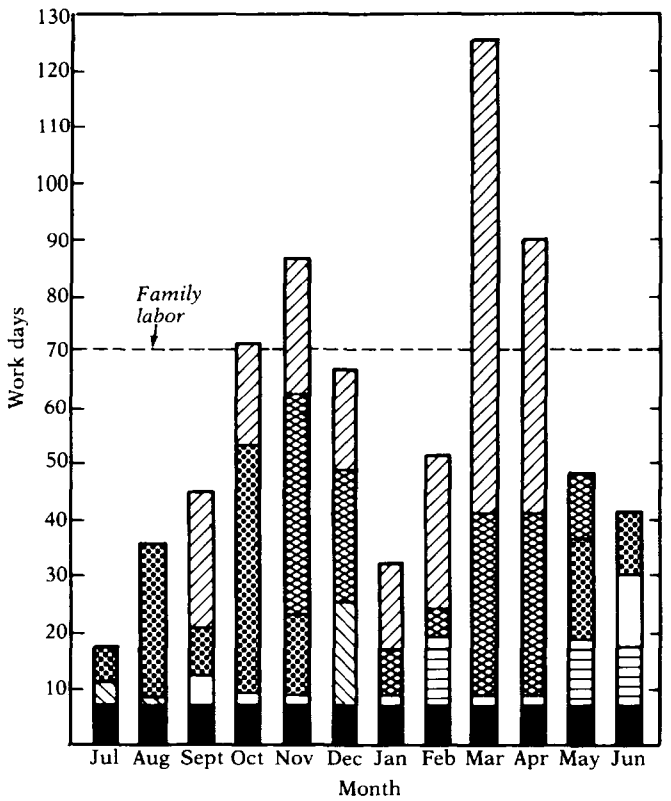
c. Area and labor requirement for sunflower apply to the year of planting. Thus, the area assumed in the first five months of project year 5 is the 2.2 hectares planted in May of project year 4.

d. Calculated on the basis of improved pasture established in previous years (as shown in table 4-4). Thus, in year 2 it is based on 3.5 hectares and in year 3 on 7.0 hectares.

Some analysts like to work out a labor use diagram such as the one shown in figure 4-3. This usually is done only for the full-development situation. The graphic presentation makes the problem of peak labor requirements readily apparent.

Once the total hired labor has been determined, it must be allocated among the various crops so that it may be included in the proper category of operating expenditure. This is done in table 4-8. In the Paraguay example the allocation is made in proportion to the total work days

Figure 4-3. *Labor Use Diagram for Project Years 7–20, 20-Hectare Mixed Farm, Paraguay Project*



Crop	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Cotton	0	0	24	18	24	18	15	27	84	48	0	0	258
Soybeans	0	0	0	0	39	24	9	6	33	33	12	0	156
Sunflower	6	27	9	45	15	0	0	0	0	0	18	12	132
Maize	4	1	0	0	0	18	0	0	0	0	0	0	23
Manioc	0	0	5	1	1	0	1	1	1	1	1	12	24
Improved pasture maintenance	0	0	0	0	0	0	0	10	0	0	10	10	30
Livestock	8	8	8	8	8	8	8	8	8	8	8	8	96
Total	18	36	46	72	87	68	33	52	126	90	49	42	719
Family labor	18	36	46	70	70	68	33	52	70	70	49	42	624
Hired labor	0	0	0	2	17	0	0	0	56	20	0	0	95

Source: Table 4-7.

required for each cash crop in each month for which hired labor would be needed. In other circumstances, such a mechanistic allocation would be inappropriate. In many areas, certain crop operations are done by hired labor and not by family labor, even if family labor is available. Thus, in Southeast Asia, transplanting rice is done in many areas entirely by hired labor; the only family labor engaged is that of the farmer himself, who supervises the work. Both the amount of hired labor and its allocation among crops should be closely related to the expected cultural practices of people in the project area.

Farm production

Having determined the use of land and labor resources for the pattern farm, the analyst next assesses the projected farm production. The investment analysis of crop and pasture and livestock production is discussed in this subsection, and issues of valuation (both of farm production and incremental residual value on the farm) are addressed.

Table 4-8. *Hired Labor by Crop and Month, 20-Hectare Mixed Farm, Paraguay Project*
(work days)

Year and crop[a]	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Total*
Year 4													
Cotton	0	0	0	0	1	0	0	0	14	0	0	0	15
Soybeans	0	0	0	0	2	0	0	0	5	0	0	0	7
Total	0	0	0	0	3	0	0	0	19	0	0	0	22
Year 5													
Cotton	0	0	0	0	3	0	0	0	23	1	0	0	27
Soybeans	0	0	0	0	5	0	0	0	9	1	0	0	15
Sunflower	0	0	0	0	1	0	0	0	0	0	0	0	1
Total	0	0	0	0	9[b]	0	0	0	32	2	0	0	43[b]
Year 6													
Cotton	0	0	0	0	4	0	0	0	40	12	0	0	56
Soybeans	0	0	0	0	7	0	0	0	16	8	0	0	31
Sunflower	0	0	0	0	2	0	0	0	0	0	0	0	2
Total	0	0	0	0	13[b]	0	0	0	56	20	0	0	89[b]
Years 7–20													
Cotton	0	0	0	1	5	0	0	0	40	12	0	0	58
Soybeans	0	0	0	0	8	0	0	0	16	8	0	0	32
Sunflower	0	0	0	1	3	0	0	0	0	0	0	0	4
Total	0	0	0	2	16[b]	0	0	0	56	20	0	0	94[b]

Source: Calculated from table 4-7.

a. Hired labor is allocated to cash crops—cotton, soybeans, and sunflower—in proportion to their total labor requirements in that month. In November of year 4, for example, 55 work days are required for cash crops, of which 3 work days are to be hired. Eighteen work days are required for cotton. To determine the hired labor for cotton, the proportion of total labor required for cash crops that is to be applied to cotton is multiplied by the total hired labor requirement for the month; this gives the hired labor to be applied to cotton, or 1 work day $\{[18 \div (18 + 29 + 8)] \times 3 = 1\}$.

b. Does not equal the total in table 4-7 because of rounding.

CROPS AND PASTURE. For *crops* and *pasture*, the yield and carrying capacity are tabulated as illustrated in table 4-9. In the table, yields are shown only for crops and pasture actually in the cropping pattern in the year reported. Thus, no without-project yield is reported for soybeans, whereas for sunflower, which will be planted following cotton in year 2, yield is reported only beginning in year 3 since the first crop is not harvested until that time.

Multiplying the production per hectare by the number of hectares of each of the *crops* and of *pasture* in the land use pattern shown in table 4-4, we obtain the crop and pasture production illustrated in table 4-10. Again, since sunflower is first planted in year 2 but first harvested in year 3, the production from the first planting of 1.8 tons is shown in year 3. Similarly, sunflower planted each year produces in the following year.

Because all the feed for the livestock to be produced on the pattern farm in the Paraguay project is assumed to come from pasture, no deduction is made in table 4-10 for crops to be used for feed. Should the production pattern of a model farm call for the use of crops and crop by-products for feed, table 4-10 would then be adjusted to show that use. *Total production* of crops would be shown and expanded to include crop by-products if these were to be fed or if they have a sale value. From this total would be deducted the *feed consumption* taken from an estimate of feed requirement and production such as that illustrated in table 4-30. The result would be the *net production available for sale or household consumption.*

LIVESTOCK. *Herd composition, purchases, and sales* are given in table 4-11. Projecting the herd (or flock) composition, purchases, and sales in a farm investment analysis that involves livestock introduces a computational process that can become quite complex.

Table 4-9. *Yield and Carrying Capacity, 20-Hectare Mixed Farm, Paraguay Project*

Product	Without project	With project						
		Year 1	2	3	4	5	6	7–20
Crops (tons per hectare)								
Maize	1.1	1.1	1.1	1.2	1.2	1.3	1 3	1.4
Manioc	18.0	18.0	18.0	20.0	20.0	22.0	22.0	24.0
Beans	0.9	0.9	0.9	1.0	1.0	1.0	—	—
Cotton	1.3	1.3	1.5	1.5	1.6	1.6	1.7	1.7
Soybeans	—	—	1.4	1.4	1.6	1.6	1.8	1.8
Sunflower	—	—	—	0.9	1.0	1.1	1.2	1.2
Pasture (animal units per hectare)								
Natural	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Improved	—	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Source: Same as table 4-4.

Table 4-10. *Crop and Pasture Production, 20-Hectare Mixed Farm, Paraguay Project*
(tons)

Product	Without project	With project						
		Year 1	2	3	4	5	6	7–20
Crops								
Total production								
Maize	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Manioc	18.0	18.0	18.0	20.0	10.0	11.0	11.0	12.0
Beans	0.4	0.4	0.4	0.5	0.5	0.5	—	—
Cotton	2.6	2.6	3.0	3.0	3.5	4.0	5.1	5.1
Soybeans	—	—	1.4	1.4	3.5	4.0	5.4	5.4
Sunflower[a]	—	—	—	1.8	2.0	2.4	3.0	3.6
Feed consumption[b]								
Maize	—	—	—	—	—	—	—	—
Manioc	—	—	—	—	—	—	—	—
Soybeans	—	—	—	—	—	—	—	—
Sunflower	—	—	—	—	—	—	—	—
Net production available for sale or household consumption								
Maize	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Manioc	18.0	18.0	18.0	20.0	10.0	11.0	11.0	12.0
Beans	0.4	0.4	0.4	0.5	0.5	0.5	—	—
Cotton	2.6	2.6	3.0	3.0	3.5	4.0	5.1	5.1
Soybeans	—	—	1.4	1.4	3.5	4.0	5.4	5.4
Sunflower	—	—	—	1.8	2.0	2.4	3.0	3.6
Pasture								
Carrying capacity (animal units)	12.6	17.2	21.7	26.2	26.2	26.2	26.2	26.2

Source: Calculated from tables 4-4 and 4-9.

a. Sunflower is harvested in the year following planting. Thus, the production in year 2 is zero, and in year 3 it is 1.8 tons, which is determined by multiplying the 2.0 hectares planted in year 2 by the yield of 0.9 tons per hectare harvested in year 3 ($2.0 \times 0.9 = 1.8$).

b. If there were a substantial livestock production activity on the farm that used crops for feed, the amounts would be estimated in a feed requirement and production table such as table 4-30 and tabulated here. The table would be expanded to include crop by-products used for feed. As indicated, the use of crops for feed would be deducted from the total production, and the result would be the net production available for sale or household consumption.

Herd projections are done to forecast use of future facilities, pasture, or feed by applying *technical coefficients*, such as those shown at the bottom of table 4-11, to trace the changes in the size and composition of the herd.

For poultry, stall feeding, or feedlot projections, it is usually assumed that enough young animals can be purchased in a given year to bring the numbers up to the level of feed availability or of proposed production facilities. Brown (1979, pp. 76–85) gives a methodology for broiler and egg production. For pigs, a projection is made applying the technical coefficients; since the gestation period of swine is short, the projection is simplified and uncomplicated.

Table 4-11. *Herd Composition, Purchases, and Sales, 100 20-Hectare Mixed Farms, Paraguay Project*
(head)

Item	Without project	With project						
		Year 1	2	3	4	5	6	7–20
Herd composition at beginning of year								
Bulls	100	100	100	100	100	100	100	100
Breeding cows	500	500	655	800	800	800	800	800
Heifers 1–2 years	157	157	157	221	294	285	285	285
Heifers 2–3 years	152	152	152	152	217	288	279	279
Steers 1–2 years	157	157	157	221	294	285	285	285
Steers 2–3 years	152	152	152	152	217	288	279	279
Steers 3–4 years	147	147	147	147	149	213	282	273
Work oxen	—	0	200	200	200	200	200	200
Total	1,365	1,365	1,720	1,993	2,271	2,459	2,510	2,501
Animal units	1,365	1,365	1,720	1,993	2,271	2,459	2,510	2,501
Carrying capacity (beginning of year)[a]	1,260	1,260	1,720	2,170	2,620	2,620	2,620	2,620
Purchases								
Bulls	18	33	20	20	20	20	20	20
Heifers 2–3 years	0	91	131	2	0	0	0	0
Steers 1–2 years	0	0	0	0	0	0	0	0
Work oxen	0	200	38	36	36	36	36	36
Total	18	324	189	58	56	56	56	56
Sales (including culls)								
Culled bulls	15	30	17	18	18	18	18	18
Culled cows	60	60	98	120	112	112	112	112
Culled heifers	8	8	15	15	22	29	28	28
Surplus heifers 2–3 years	64	0	0	0	63	125	117	117
Steers 1–2 years	0	0	0	0	0	0	0	0
Steers 3–4 years	143	143	143	144	146	209	276	268
Culled work oxen	—	0	32	32	32	32	32	32
Total	290	241	305	329	393	525	583	575
Herd productivity (percent)[b]	20							23
Technical coefficients (percent)								
Calving rate	70	70	75[c]	80[c]	75	75	75	75
Calf mortality	10	10	10	8	5	5	5	5
Adult mortality	3	3	3	2	2	2	2	2
Culling rate (bulls)	15	30	17	18	18	18	18	18
Culling rate (cows)	12	12	15	15	14	14	14	14
Culling rate (heifers)	5	5	10	10	10	10	10	10
Culling rate (work oxen)	—	0	16	16	16	16	16	16
Bulls/breeding females[d]	—	—	—	—	—	—	—	—
Carrying capacity (per hectare; end of year)[a]	1.2	1.6	2.1	2.5	2.5	2.5	2.5	2.5

Source: Same as table 4-4 (annex 1, table 18). See computations in table 4-27.

a. In animal units. The carrying capacity at the beginning of the year is determined by multiplying the animal units per farm at the end of the previous year (given in table 4-10) by the 100 farms in the model. The carrying capacity per hectare at the end of the year is determined by dividing the animal units per farm by the 10.5 hectares of pasture on each farm; it is thus a weighted average of natural and improved pasture.

(Notes continue on the following page.)

The projection can become computationally quite complicated, however, for larger animals fed mainly pasture, such as sheep or cattle used for dairy or beef production. The project analyst often relies on the livestock technician for these projections and simply incorporates them into his farm investment analysis. But livestock technicians themselves may be unfamiliar with the details of how to make these computations—and especially with how to make them so they conform to the accounting convention adopted here for the farm investment analysis. For this reason, the computation for the herd projection in the Paraguay example is discussed in considerable detail in the appendix to this chapter (where definitions of the specialized livestock terms may also be found). This methodology can be adapted, with only minor variations, to projections for dairy animals. As in the treatment here, the details of the projection need not form part of the main body of most project reports; only a summary need be given (as in table 4-11 from the Paraguay example), with the details laid out in an annex or in the project file.

Projecting the herd composition on a small farm when larger animals are to be produced introduces the difficult problems of divisibility. As noted, herd projections for animals that are mainly grazed on pasture are based on the estimated feed availability. Technical coefficients, such as mortality and calving rates, are often directly influenced by the amount of available feed, but in cattle production changes do not happen immediately. For example, an increase in feed availability in one season will improve the calving rate and decrease calf losses only during the next season.

The projected coefficients are applied to the herd at the beginning of the project. The result begins to appear in the herd composition at the beginning of year 2. Often, the projected coefficients indicate that the herd's composition and its overall size will not change fast enough to utilize the increased feed available. As a solution, in-calf heifers can be purchased to increase the reproductive component of the herd, or feeder steers can be purchased for fattening until the herd can utilize the forage resources.

This use of technical coefficients raises few problems of interpretation for larger farms or ranches with herds of 100 or more animals. For small farms, however, the technical coefficients lead to many "fractional animals." In the Paraguay example, for instance, at full development from years 7 through 20 the farm is expected to have eight breeding cows. The adult mortality is expected to be 2 percent, so do we report that 0.16 cows die each year ($8 \times 0.02 = 0.16$)? Such nonsensical results have led project

b. Herd productivity is the sum of the off-take rate and the herd growth rate. Only the values for a stable herd are given.

c. Represents a weighted average between the calving rate of breeding cows in the existing herd, which is 70 percent, and that of purchased in-calf heifers, which is nearly 100 percent.

d. Note that in this project a minimum of one bull per farm is assumed, or a minimum of 100 bulls on 100 farms. Normally the number of bulls per 100 breeding females would be three or four for all years.

analysts to seek means to overcome the divisibility problem. Some have simply ignored technical coefficients, such as mortality, that result in very small, fractional animal figures. This omission, however, considerably distorts the pattern farm investment analysis. To avoid such distortion, other analysts have devised systems that carry fractional animals in the computation until the fractions add up to a whole animal, which is then reported. In the Paraguay example, for instance, the calving rate at full development is 75 percent. Thus, six calves are born, of which half may be expected to be female. Calf mortality is 5 percent, and this gives a figure of 2.8 to be carried over to the next year as heifers 1–2 years old [$8 \times 0.75 \div 2 - (8 \times 0.75 \div 2 \times 0.05) = 2.8$]. Of these, 2 percent are reported and 0.8 is carried over to the following year, which then will show a figure of 3.6 (0.8 + 2.8 = 3.6). Of these, 3 are reported and 0.6 is carried forward, and so forth.

Mortality may sometimes be treated by incorporating a more formal probability assumption. Such systems become quite complex and in the end do not satisfactorily project an individual small herd. Another approach that is increasingly used—and that is adopted and recommended here—is to do the herd projection for a number of farms, say 100, that will contain or eliminate the divisibility problem. Purchases and sales are then valued, and only the values are entered in the farm investment analysis for a single pattern farm. In effect, this says that *on the average* a farm will have a certain level of purchases and sales. This, too, is not a fully satisfactory convention. Its results do not state, for example, how many animals are actually on the farm at any given time. It does have the virtue, however, of being simpler than other systems—even if it is still quite complex—and of generating somewhat less distortion.

Project designers may want to introduce an insurance scheme to protect project participants from, say, the loss of a bull. Then, in effect, the values in the farm investment analysis for a single farm for the purchase of bulls include an insurance premium that insures that the farmer will be reimbursed in the event of the death of a bull. Such insurance schemes are found in developing countries, but they give rise to possibilities of abuse and to difficult administrative problems, and they often are not very effective.

In the Paraguay example summarized in table 4-11, the *herd composition* is given for each major class of animals without the project and for each project year. (The table is drawn from the worksheet reproduced in table 4-27.) Note that the analyst assumed that each farm would have a bull, so that the number of bulls remains 100, many more than would be needed if the analysis were, indeed, for a single herd rather than for 100 small farms. Note, also, the purchase of draft animals at the end of the first year. It is assumed that each farm will purchase two work oxen. The total *animal units* for the herd are shown, and for convenience this figure is compared with the *carrying capacity*. As noted in the appendix to this chapter, the number of breeding cows has been rounded to an even multiple of the number of farms in the model so that each farm has five breeding cows without the project and increases its herd to eight breed-

ing cows at full development. As a result, the total of animal units does not very closely approximate the carrying capacity. Since estimates of carrying capacity are quite approximate, however, overstocking of up to 10 percent would probably be acceptable.

Purchases of each class of animal are treated next in the investment analysis; these will form the basis for the investment and operating expenditure for the livestock aspect of the 20-hectare mixed farm. The *sales* give the basis for the inflow for the farm. The *herd productivity*, a measure of the efficiency of the herd, is also given; it relates the number of head sold plus the increase in herd size to the number of head carried at the beginning of the year. Only the figures for the stable herd without the project and at full development are given. The dynamics of herd growth tend to distort the measure during the period when the herd is increasing in size. (The details of the computation are given in table 4-28.) Finally, the *technical coefficients* for the herd are given. These are crucial parameters of the herd growth and are indicators of management effectiveness, animal health care, and feed availability.

When feed concentrates are important in the farm production pattern, it may be desirable to project the feed requirements the livestock activity will involve. (An illustrative example is included in tables 4-29 and 4-30 in the appendix to this chapter in connection with the discussion of herd projections.)

In some instances it may be desirable to report yield per animal if the valuation system is based, say, on kilograms. In the Paraguay example the prices are based on individual animals without regard to weight, so yield per animal is not needed and is therefore not illustrated.

VALUATION. To begin the valuation of the farm production, the farm-gate prices for items entering the farm investment analysis are listed as shown in table 4-12. (The symbol for Paraguayan guaranis is ₲.) If a farm-gate price is used in only one table of the investment analysis, it may not be included in the farm-gate price table but may appear in the appropriate table. (Such is the case, for example, of the prices for land improvement, which are included in table 4-15, devoted to investment, and not in the table of farm-gate prices.) Some farm-gate prices were collected and projected by the project analyst on the basis of field observation. Other prices were collected in the field but forecast using the projections of the World Bank. Prices and their derivation were discussed in more detail in chapter 3.

The value of production for the farm is given in table 4-13. For *crops*, values are determined by multiplying the production in table 4-10 by the price per ton in table 4-12. For *livestock*, the value is obtained by multiplying sales from table 4-11 by the price per animal given in table 4-12. The product is then divided by 100 to give the value for a single farm, in line with the convention recommended to avoid the divisibility problem.

INCREMENTAL RESIDUAL VALUE. In the last year of the farm investment analysis, the incremental residual (or terminal) value on the farm is

Table 4-12. *Farm-Gate Prices, 20-Hectare Mixed Farm, Paraguay Project*
(thousands of ₲)

Item[a]	Project year			
	1	*2*	*3–5*	*6–20*
Farm labor (per work day)	0.3	0.3	0.3	0.3
Crops (per ton)				
Maize	12.0	12.0	12.0	12.0
Manioc	3.0	3.0	3.0	3.0
Beans	28.0	28.0	28.0	28.0
Cotton	44.4	45.1	45.1	44.9
Soybeans	23.6	20.9	26.2	28.9
Sunflower	20.0	20.0	20.0	20.0
Livestock (per head)				
Bulls	30.0	30.0	32.4	33.6
Culled bulls	23.0	23.0	24.8	25.8
Breeding cows	18.7	18.7	20.2	20.9
Culled cows	17.0	17.0	18.4	19.0
Heifers 1–2 years	12.5	12.5	13.5	14.0
Heifers 2–3 years	18.7	18.7	20.2	20.9
Culled heifers 2–3 years	17.0	17.0	18.4	19.0
Steers 1–2 years	12.5	12.5	13.5	14.0
Steers 2–3 years	18.7	18.7	20.2	20.9
Steers 3–4 years	23.0	23.0	24.8	25.8
Work oxen	35.0	35.0	37.8	39.2
Culled work oxen	23.0	23.0	24.8	25.8

₲ Paraguayan guaranis.
Source: Same as table 4-4.
a. Prices of maize, soybeans, and livestock are adjusted for the real price changes projected by the Commodities and Export Projections division of the World Bank. Other prices are assumed to remain constant in real terms.

included among the inflows in the farm budget and "credited" to the project investment. This is done because not all the utility of an investment may be exhausted in the course of a project. Note that it is the *incremental value* that is sought, not the total value. In some instances there is no distinction, since the value of an item such as construction may be entirely incremental. But for items such as land, livestock, and working capital, there may have been values existing at the beginning of the project, and only the incremental residual value may properly be credited to the project investment. Since the incremental residual value enters the farm investment analysis in the final year, it bears relatively little weight in the discounting process. As a result, rather broad estimates of residual values are acceptable in project analysis.

Three kinds of residual value may be noted. The first is the salvage value of capital assets that have been largely consumed by the end of the project and that, for the most part, can only be salvaged for their scrap value or have only a short portion of their normal life expectancy remaining at the end of the project period. Buildings and other construction or machinery such as irrigation pumps or tractors are common examples. A second kind of residual value is the working capital. This is automati-

cally allowed for under the accounting convention we have adopted for the farm investment analysis. The third kind of residual value is the value of items that have a substantial useful life remaining at the end of the project and may even have increased in value as a result of the project investment; land with associated improvements and a livestock herd are examples.

All three kinds of residual value are illustrated for the Paraguay example in table 4-14. In a land improvement project such as this one, there usually would be an entry for the incremental value of *land*, although in this instance the analyst chose not to include it because the site in Paraguay is a frontier area and the land market is not very active. In more crowded societies where a project involves land improvement such as better irrigation and drainage, the incremental value of the land might be quite substantial. Next for consideration would be the incremental residual value of *construction*. In the Paraguay example, the construction is all incremental, so the incremental residual value is quite simply obtained by taking a proportion of the initial construction, in this case 10 percent. The incremental residual value of *equipment* is assumed to be negligible, although that would not necessarily be the case in other projects. Then the analyst considers the incremental value of *livestock*. In this case, care must be taken to distinguish between the total residual value of the livestock herd and the incremental residual value. There was, of course, a livestock herd at the beginning of the project, so only the increased value of the herd at the end of the project can be attributed to the project investment itself. Hence, each class of animals is valued at the beginning of the project and at the end of the project, and only the difference—or increment—is carried forward as the incremental residual value. Finally, there is the total incremental *working capital*. The reader will recall that, in the discussion of the accounting convention for farm investment analysis, considerable attention was devoted to estimating the incremental working capital year by year. Once this is done, all that is needed to obtain the total incremental working capital is simply to add the incremental working capital for each year algebraically—that is, adding the increases and subtracting decreases—to obtain the incremental residual value entered in the final year.

Farm inputs

When the estimates of production are complete, the estimates of the necessary inputs may be prepared. Inputs comprise the investment, operating expenditure, and incremental working capital for the project.

INVESTMENT. Investment for the project is a crucial element. The investment contemplated for the Paraguay pattern farm is given in table 4-15. It is convenient to show the unit and unit cost in the investment table; for convenience, items appearing only in the investment table may be omitted from the farm-gate price table. As in this presentation, the total physical investment may be incorporated in the investment cost

Table 4-13. *Value of Production, 20-Hectare Mixed Farm, Paraguay Project*
(thousands of ₲)

Item	Without project				With project						
	Year 1	*2*	*3–5*	*6–20*	*1*	*2*	*3*	*4*	*5*	*6*	*7–20*
Crops[a]											
Maize	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	8.4
Manioc	54.0	54.0	54.0	54.0	54.0	54.0	60.0	30.0	33.0	33.0	36.0
Beans	11.2	11.2	11.2	11.2	11.2	11.2	14.0	14.0	14.0	—	—
Cotton	115.4	117.3	117.3	116.7	115.4	135.3	135.3	157.8	180.4	229.0	229.0
Soybeans	—	—	—	—	—	29.3	36.7	91.7	104.8	156.1	156.1
Sunflower	—	—	—	—	—	—	36.0	40.0	48.0	60.0	72.0
Total	187.8	189.7	189.7	189.1	187.8	237.0	289.2	340 7	387.4	485.3	501.5
Livestock[b]											
Culled bulls	3.4	3.4	3.7	3 9	6.9	3.9	4.5	4.5	4.5	4.6	4.6
Culled cows	10.2	10.2	11.0	11.4	10.2	16.7	22.1	20.6	20.6	21.3	21.3
Culled heifers	1.4	1.4	1.5	1.5	1.4	2.6	2.8	4.0	5.3	5.3	5.3
Surplus heifers	12.0	12.0	12.9	13.4	0	0	0	12.7	25.2	24.5	24.5
Steers 3–4 years	32.9	32.9	35.5	36.9	32.9	32.9	35.7	36.2	51.8	71.2	69.1
Culled work oxen	—	—	—	—	—	7.4	7.9	7.9	7.9	8.3	8.3
Total	59.9	59.9	64.6	67.1	51.4	63.5	73.0	85.9	115.3	135.2	133.1
Total value	247 7	249.6	254.3	256.2	239.2	300.5	362.2	426 6	502.7	620.5	634.6

Source: Calculated from tables 4-10, 4-11, and 4-12.

a. Production from table 4-10 multiplied by the price per ton from table 4-12. For year 2 without the project, for example, the value of cotton is the without-project production from table 4-10 times the price in year 2 in table 4-12.

b. Sales from table 4-11 multiplied by the price per animal from table 4-12; product is then divided by 100 to give the value for a single farm. See text for a discussion of this convention.

Table 4-14. *Incremental Residual Value, 20-Hectare Mixed Farm, Paraguay Project*
(thousands of ₲)

Item	Value		
	At beginning of project	*At end of project*	*Incremental*
Land	[a]	[a]	[a]
Construction[b]	0	18.0	18.0
Equipment[c]	0	0	0
Livestock[d]			
Bulls	30.0	33.6	
Breeding cows	93.5	167.2	
Heifers 1–2 years	19.6	39.9	
Heifers 2–3 years	28.4	58.3	
Steers 1–2 years	19.6	39.9	
Steers 2–3 years	28.4	58.3	
Steers 3–4 years	33.8	70.4	
Work oxen	—	78.4	
Total	253.3	546.0	292.7
Working capital[e]	—	—	119.9
Total			430.6

Source: Calculated from other tables as noted.

a. In the Paraguay example, the analyst chose not to include an incremental value of land improvements in his computation of residual value. This amount usually is included if there has been substantial land improvement.

b. The residual value of construction is taken as 10 percent of the total construction investment given in table 4-15.

c. The residual value of equipment is assumed to be negligible. Only equipment purchased for the project is included in the computation, not the equipment existing on the farm at the beginning of the project.

d. The value of the livestock at the beginning of the project is calculated from the herd composition at the beginning of the year in table 4-11 multiplied by the year-1 prices in table 4-12. The value of the livestock at the end of the project is calculated from the year-20 herd composition in table 4-11 multiplied by the year-20 prices in table 4-12.

e. From table 4-17.

table; in other instances, a separate table may be needed. Although it is not shown for the Paraguay example, including the foreign exchange component of the investment cost is often desirable. It is important that an agricultural project report detail the foreign exchange needed for the project because the availability of foreign exchange may be a major constraint.

Investment for the Paraguay example is divided into *land improvement, construction, equipment,* and *livestock,* the major categories likely to be found in an agricultural project. Within each category the major items are noted, and the investment for them is tabulated by project year. The total investment by year and for the pattern as a whole is given. Note how the analyst accommodated the existing equipment found on project farms in this pattern by listing equipment totaling ₲206 thousand, but then subtracting ₲50 thousand as an average of existing equipment.

For livestock, it is assumed that all heifer purchases and culling in excess of that normally done without the project are an investment.

Table 9-15. *Internal Rate of Return Calculation Illustrating Multiple Solutions, Oil Well Project*
(thousands of US$)

Year	*Incremental net benefit (cash flow)*	*Discount factor 20%*	*Present worth 20%*	*Discount factor 25%*	*Present worth 25%*	*Discount factor 40%*	*Present worth 40%*	*Discount factor 45%*	*Present worth 45%*
1–4	+ 50	2.589	+129	2.362	+118	1.849	+ 92	1.720	+ 86
5	−750	0.402	−302	0 328	−246	0.186	−140	0 156	−117
6–20	+100	1.879	+188	1.265	+126	0.462	+ 46	0 345	+ 34
Total	+950	4.870	+ 15	3.955	− 2	2.497	− 2	2.221	+ 3

Source: Grant and Ireson (1964, p. 509).

that the cumulative present worth up to that point is positive, there then occur negative cash flows such that the present worth at t_0 of the cash flow from a given year onward (discounted in the normal way) is negative. Under such circumstances there *may* be more than one discount rate that will bring the present worth of the cash flow down to zero, although this will not necessarily be the case.

Negative incremental net benefits for particular years are sometimes found in agricultural projects. They can arise, for instance, when pumps must be replaced in an irrigation system or at the beginning of a replanting cycle in a crops project. Usually, however, the negative incremental net benefit flows late in the project will have to be quite large for there to be multiple solutions. An occasional negative year, or a final year or two of negative incremental net benefits, will almost never give rise to multiple solutions.

The kind of situation in which there are large negative cash flows after the initial investment phase of the project, although it is rare in agriculture, can be found in natural resources projects. To illustrate a multiple solution, we may consider an example of such a natural resources project given by Grant and Ireson (1964, pp. 509–10). Take the case of an oil company that is offered a lease on a group of wells for which the primary oil reserves are close to exhaustion. The major condition of the purchase is that the oil company must agree to undertake the injection of water into the underground reservoir to make possible a secondary recovery at the time the primary reserves are exhausted. The lessor will receive a standard royalty from all oil produced from the property whether from the primary or secondary reserves. No immediate payment from the oil company is required. The company estimates it will realize US$50 thousand a year for five years before exhausting the primary reserves. Then it must expend US$800 thousand for the water-injection project—the large negative cash flow—after which it will realize US$100 thousand a year for the following fifteen years. The internal rate of return calculation for this example is shown in table 9-15.

From the standpoint of agricultural project analysis, this is a curiosity of internal rate of return theory that has virtually no practical importance. In fact, I have been unable to find an agricultural example from a real project that illustrates the point, and I would appreciate learning of such an example should the reader find one. If such a case exists in an agricultural project, the analytical problem can be resolved by using either the "extended yield" method or the "auxiliary interest rate" method. A discussion of these methods can be found in Merrett and Sykes (1963, pp. 158–65) and Grant and Ireson (1970, pp. 546–65).

Point in time for internal rate of return calculations

Internal rate of return calculations can be done from any point in time, and all points will give the same return. In our illustrations we always calculate from t_0 into the future because this simplifies the calculation. But if we chose the end of the project, for example, we could increase by

Table 9-16. *Benefit-Cost Computation Comparing Gross Benefit with Gross Cost, Ilocos Project*
(millions of US$)

Year	Incremental cost				Discount factor 12%	Present worth 12%	Value of incremental production (gross benefit)	Discount factor 12%	Present worth 12%
	Capital items	Operation and maintenance	Production	Gross					
1	1 09	0	0	1 09	0 893	0.97	0	0 893	0
2	4 83	0	0	4 83	0 797	3 85	0	0 797	0
3	5.68	0	0	5 68	0.712	4.04	0	0 712	0
4	4.50	0	0	4.50	0 636	2 86	0	0 636	0
5	1 99	0	0	1 99	0.567	1 13	0	0 567	0
6	0	0 34	0 33	0.67	0 507	0.34	1 67	0.507	0.85
7	0	0 34	0.63	0 97	0.452	0 44	3 34	0 452	1 51
8	0	0 34	0.96	1.30	0 404	0 53	5 00	0 404	2.02
9	0	0 34	1 28	1 62	0 361	0 58	6 68	0 361	2.41
10–30	0	0.34[a]	1.61[a]	1 95[a]	2.727[b]	5 32	8.38[a]	2.727[b]	22 85
Total	18 09	8 50	37.01	63 60	8.056	20 06	192 67	8 056	29.64

Benefit-cost ratio at 12 percent = US$29 64 − US$20 06 = 1 48
Net present worth at 12 percent = US$29 64 − US$20 06 = US$+9.58

Source Same as table 9-9

a Annual amount for years 10 through 30 inclusive. To reach column total, this amount must be included 21 times.

b Present worth of an annuity factor for years 10 through 30 inclusive. See the subsection "Present worth of a stream of future income" for method of computation.

compound interest factors all values in the incremental net benefit stream and find the interest rate that just makes the stream equal zero. If we were to designate a point midway through the project period as t_0, we could increase all values before the time from which we choose to work (say from t_{-5} to t_{-1}) by compound interest factors and draw down all future values (say from t_{+1} to t_{+14}) by using discount factors. Again, we would be looking for that interest rate which makes the value of the incremental net benefit stream at t_0 equal zero.

Benefit-Cost Ratio

A third discounted measure of project worth is the benefit-cost ratio. This is the ratio obtained when the present worth of the benefit stream is divided by the present worth of the cost stream. (For a more formal mathematical statement, see the appendix to this chapter.)

Incidentally, economists are quite inconsistent in their use of benefit-cost ratio. About half the time they say "cost-benefit" ratio. Here, however, I will stick to benefit-cost ratio to emphasize the computation by which the measure is worked out.

The benefit-cost ratio is not commonly used in developing countries. This is because the value of the ratio will change depending on where the netting out in the cost and benefit streams occurs. (Further on in this section we will illustrate how this works.) The benefit-cost ratio was the first of the discounted measures of project worth to become well known. It is extensively employed in the United States for water resource projects, although it is now increasingly being replaced by a variation of the net present worth criterion. Many economists in developing countries who have studied in the United States or who are familiar with U.S. practice will know of the benefit-cost measure. By the time discounted measures of project worth began to be applied in developing countries, the discounted cash flow measures of net present worth and internal rate of return had become well known and were being widely used for private investment. Since discounted cash flow measures do not change when different conventions for netting out are used, they are easier to apply and were thus adopted by development economists.

We return to the Philippine Ilocos Irrigation Systems Improvement Project analyzed in tables 9-9 through 9-11 to show how the benefit-cost ratio is calculated. In table 9-16, the gross benefit is compared with the gross cost. The present worth of the gross incremental cost stream at 12 percent is found to be US$20.06 million, whereas the present worth of the value of incremental production or gross benefit stream is found to be US$29.64 million. Dividing the present worth of the gross benefit stream by the present worth of the gross cost stream, we find the benefit-cost ratio to be 1.48 ($29.64 \div 20.06 = 1.48$).

Had the benefit-cost ratio worked out to be less than 1, then the present worth of the costs at this discount rate would have exceeded the present

Table 9-17. *Benefit-Cost Computation Comparing Net Benefit with Investment plus Operation and Maintenance Cost, Ilocos Project*
(millions of US$)

Year	Incremental cost			Discount factor 12%	Present worth 12%	Value of incremental production (gross benefit)	Incremental production cost	Net value of incremental production	Discount factor 12%	Present worth 12%
	Capital items	Operation and maintenance	Total							
1	1.09	0	1.09	0.893	0.97	0	0	0	0.893	0
2	4.83	0	4.83	0.797	3.85	0	0	0	0.797	0
3	5.68	0	5.68	0.712	4 04	0	0	0	0.712	0
4	4.50	0	4.50	0.636	2.86	0	0	0	0.636	0
5	1.99	0	1.99	0.567	1.13	0	0	0	0.567	0
6	0	0.34	0.34	0.507	0.17	1.67	0.33	1.34	0.507	0.68
7	0	0.34	0.34	0.452	0.15	3.34	0.63	2.71	0.452	1.22
8	0	0.34	0.34	0 404	0 14	5.00	0.96	4.04	0.404	1.63
9	0	0.34	0.34	0.361	0.12	6.68	1.28	5.40	0.361	1.95
10–30	0	0.34[a]	0.34[a]	2.727[b]	0.93[a]	8.38[a]	1.61[a]	6.77[a]	2.727[b]	18 46
Total	18.09	8 50	26.59	8.056	14.36	192.67	37.01	155.66	8.056	23.94

Benefit-cost ratio at 12 percent = US$23.94 − US$14.36 = 1.67
Net present worth at 12 percent = US$23.94 − US$14.36 = US$+9.58

Source: Same as table 9-9.

a. Annual amount for years 10 through 30 inclusive. To reach column total, this amount must be included 21 times.

b. Present worth of an annuity factor for years 10 through 30 inclusive. See the subsection "Present worth of a future stream of income" for method of computation.

worth of the benefits, and we would not have recovered our initial expenditure plus the return on our investment from the project.

Note that the absolute value of the benefit-cost ratio will vary depending on the interest rate chosen. The higher the interest rate, the smaller the resultant benefit-cost ratio, and, if a high enough rate is chosen, the benefit-cost ratio will be driven down to less than 1.

The formal selection criterion for the benefit-cost ratio measure of project worth is to accept all independent projects with a benefit-cost ratio of 1 or greater when the cost and benefit streams are discounted at the opportunity cost of capital. In the case of mutually exclusive projects, the benefit-cost ratio can lead to an erroneous investment choice. The danger can be avoided most easily by using the net present worth criterion for mutually exclusive projects.

One convenience of the benefit-cost ratio is that it can be used directly to note how much costs could rise without making the project economically unattractive. In table 9-16, for example, we can tell by inspection that costs could rise by 48 percent before the benefit-cost ratio would be driven down to 1. With a little manipulation—taking the reciprocal of the benefit-cost ratio and subtracting it from 1—we can tell that benefits could fall by 32 percent before the ratio would be driven down to one [$1 - (1 \div 1.48) = 0.32$; $29.64 - (29.64 \times 0.32) = 20.16$; $20.16 \div 20.06 = 1.00$]. In effect, this is a quick means to estimate two "switching values." (A switching value is the amount an element of a project can change before the project becomes an unacceptable investment—see the section devoted to this topic in chapter 10.)

In practice, it is probably more common not to compute the benefit-cost ratio using gross cost and gross benefit, but rather to compare the present worth of the net benefit with the present worth of the investment cost plus the operation and maintenance cost. This reflects U.S. government practice. More specifically, the ratio is computed by taking the present worth of the gross benefit less "associated" cost and then comparing it with the present worth of the "project economic cost." The associated cost is "the value of goods and services over and above those included in project costs needed to make the immediate products or services of the project available for use or sale." Project economic cost is "the sum of installation costs; operation, maintenance, and replacement costs; and induced costs." The induced cost is "uncompensated adverse effects caused by the construction and operation" of the project. Table 9-17 illustrates how the benefit-cost ratio may be computed using this convention. (It is assumed there are no induced effects.) You will note one result of computing the benefit-cost ratio using this convention of netting out is to make it larger than when the gross cost is compared to the gross benefit. [The terms cited above, and further details of U.S. government practice, can be found in "Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning" (U.S. Government 1979).]

We may use tables 9-16 and 9-17 to illustrate the point made earlier about the advantage discounted cash flow measures have with regard to

the netting-out convention. When we changed the netting-out convention from comparing gross benefit with gross cost in table 9-16 to comparing the net benefit with investment plus operation and maintenance cost in table 9-17, we found that the benefit-cost ratio increased from 1.48 to 1.67. But the net present worth did not change when we changed the netting-out convention. It remained US$9.58 million in both cases.

Although in practice projects with higher benefit-cost ratios are often regarded as being preferable (other things being equal), ranking by benefit-cost ratio can lead to an erroneous investment choice. The benefit-cost ratio discriminates against projects with relatively high gross returns and operating costs, even though these may be shown to have a greater wealth-generating capacity than that of alternatives with a higher benefit-cost ratio. McKean (1958, pp. 107–16) discusses this point with illustrative examples.

Although different conventions for netting out costs and benefits may have been used for different projects, no matter how the netting out is done the same group of projects will be accepted if the benefit-cost ratio criterion, strictly construed, is used. In other words, the same group of projects will have benefit-cost ratios of 1 or greater. But a different netting-out convention can change the value of the ratio, as we have seen when two alternative conventions were applied to the same project in tables 9-16 and 9-17. These points are proven true by observation. If the present worth of the benefit stream exceeds the present worth of the cost stream, then the benefit-cost ratio will obviously be greater than 1. However, moving a cost from the denominator and subtracting it from the numerator—as we did when we omitted the production cost from the gross cost stream and instead deducted it from the gross benefit stream—will change the ratio value (and perhaps the rank of a project in comparison with alternatives), although the ratio will, of course, remain greater than 1.

When the benefit-cost ratio is used as a criterion for evaluating projects in a country, it is desirable that all analysts working in the country follow a common netting-out convention to derive their cost and benefit streams. If they do, they can greatly reduce the chances of a misleading indication of choice should administrators rank projects by their ratio values (as they have a tendency to do, despite the restrictions of the formal choice criterion).

Net Benefit-Investment Ratio

We have noted that none of the three discounted measures of project worth we have thus far examined can be relied upon to rank projects. The formal selection rule for each is to accept *all* projects that meet the criterion—a net present worth of zero or greater at the opportunity cost of capital, an internal rate of return equal to or greater than the opportunity cost of capital, or a benefit-cost ratio of 1 or greater at the opportunity cost of capital. Yet in many instances it is convenient to have a

reliable measure to rank projects to determine the order in which projects should be undertaken. Such a need is common in practice. Decision-makers often ask that projects be ranked, and a need for ranking arises, for example, when the capital budget is not sufficient to implement immediately all projects being considered. If projects could be ranked, then the ones with highest priority could be chosen for implementation.

A suitable and very convenient criterion for ranking independent projects (that is, those which are not mutually exclusive) that is reliable in all but the most extreme cases is the net benefit-investment ratio (also called the N/K ratio). This is simply the present worth of the net benefits divided by the present worth of the investment; it is a form of the benefit-cost ratio. (For a more formal mathematical statement, see the appendix to this chapter.) The net benefit-investment ratio has been infrequently used in project analysis, perhaps because it has been common practice to rank projects using the internal rate of return or the benefit-cost ratio. As the limitations of these other discounted measures of project worth for ranking projects become better appreciated, it is probable that the net benefit-investment ratio or some close variant will become more widely used.

The net benefit-investment ratio is simple to determine when an incremental net benefit, or cash flow, has been calculated for a project. This is so because the net benefit may be taken to be the net present worth of the incremental net benefit stream in those years after the stream has turned positive, and investment may be taken to be the present worth of the incremental net benefit stream in those early years of the project when the stream is negative. Thus, to calculate this measure, simply divide the sum of the present worths after the incremental net benefit stream has turned positive by the sum of the present worths of the negative incremental net benefits in the early years of the project.

Our discussion of the net benefit-investment ratio will concentrate on its application. A more extensive and formal discussion can be found in Helmers (1979, pp. 99–117).

We may illustrate computation of the net benefit-investment ratio by again referring to the Ilocos irrigation example from the Philippines that we have used to illustrate other discounted measures of project worth. The computation is laid out in table 9-18. The present worth of the incremental net benefit stream at 12 percent after the stream has turned positive is US$22.43 million (0.51 + 1.07 + 1.49 + 1.83 + 17.53 = 22.43). This, then, is the present worth of the net benefit. The present worth of the negative incremental net benefits at 12 percent in the early years of the project, which is the present worth of the investment, is US$12.85 million (0.97 + 3.85 + 4.04 + 2.86 + 1.13 = 12.85). We may ignore the negative signs, since the net benefit-investment ratio is stated as a positive expression. The net benefit-investment ratio thus is 1.75 (22.43 ÷ 12.85 = 1.75).

An incremental net benefit stream usually will be negative for the first few years of a project and then turn positive each year thereafter for the remaining life of the project. This is the case, for example, in the Philip-

Table 9-18. *Net Benefit-Investment (N/K) Ratio Computation, Ilocos Project*
(millions of US$)

Year	Incremental cost				Value of incremental production (gross benefit)	Incremental net benefit (cash flow)	Discount factor 12%	Present worth 12%
	Capital items	Operation and maintenance	Production	Gross				
1	1.09	0	0	1.09	0	− 1.09	0.893	− 0.97
2	4.83	0	0	4.83	0	− 4.83	0.797	− 3.85
3	5.68	0	0	5.68	0	− 5.68	0.712	− 4.04
4	4.50	0	0	4.50	0	− 4.50	0.636	− 2.86
5	1.99	0	0	1.99	0	− 1.99	0.567	− 1.13
6	0	0.34	0.33	0.67	1.67	+ 1.00	0.507	+ 0.51
7	0	0.34	0.63	0.97	3.34	+ 2.37	0.452	+ 1.07
8	0	0.34	0.96	1.30	5.00	+ 3.70	0.404	+ 1.49
9	0	0.34	1.28	1.62	6.68	+ 5.06	0.361	+ 1.83
10–30	0	0.34[a]	1.61[a]	1.95[a]	8.38[a]	+ 6.43[a]	2.727[b]	+17.53
Total	18.09	8.50	37.01	63.60	192.67	+129.07	8.056	+ 9.58

$$\text{N/K ratio at 12 percent} = \frac{\text{Present worth of net benefits at 12 percent}}{\text{Present worth of investments at 12 percent}}$$

$$= \frac{\text{Present worth of positive incremental net benefit at 12 percent}}{\text{Present worth of negative incremental net benefit at 12 percent}}$$

$$= \frac{\text{US\$0.51 + US\$1.07 + US\$1.49 + US\$1.83 + US\$17.53}}{\text{US\$0.97 + US\$3.85 + US\$4.04 + US\$2.86 + US\$1.13}} = \frac{\text{US\$22.43}}{\text{US\$12.85}} = 1.75$$

Source: Same as table 9-9.

a. Annual amount for years 10 through 30 inclusive. To reach column total, this amount must be included 21 times.

b. Present worth of an annuity factor for years 10 through 30 inclusive. See the subsection on "Present worth of a stream of future income" for method of computation.

pine irrigation illustration in table 9-18. It might happen, however, that an investment in the project at some later year would be large enough to turn the incremental net benefit for that year negative. An example might be the year when the pumps are replaced in an irrigation project. This does not affect the means of calculating the net benefit-investment ratio. The net benefit will be the present worth of the incremental net benefit stream after the stream has turned positive, and the negative incremental net benefit that occurs later in the project is simply included in the net present worth of the benefit stream—reducing the stream, obviously, below what it would otherwise have been. The reason for calculating the net benefit-investment ratio in this manner is that we are interested in an investment measure that selects projects on the basis of return to investment during the initial phases of a project. An occasional negative incremental net benefit later in the life of a project does not increase the capital needed during the investment phase of the project.

The formal selection criterion for the net benefit-investment ratio measure of project worth is to accept all projects with a net benefit-investment ratio of 1 or greater when they are discounted at the opportunity cost of capital—in order, beginning with the largest ratio value and proceeding until available investment funds are exhausted.

Selecting independent projects in the order of their net benefit-investment ratio maximizes the return per unit of available investment. This, in turn, maximizes the net present worth of the group of projects chosen, and thus maximizes the income stream that is the objective of the program of project investments.

If the net benefit-investment ratio is used to rank projects, some limitations should be kept in mind. First and most important, the net benefit-investment ratio can be used to rank mutually exclusive projects only when the net benefit-investment ratios of all projects in the investment program are known. Because in practice this would either be impossible or analytically very complex, it is better practice to select among mutually exclusive projects by using the net present worth criterion. Second, there can be instances when the net benefit-investment ratio can indicate incorrect investment decisions, but they are so extreme that they may be ignored when any real project is under consideration. Finally, the net benefit-investment ratio does not hold if one is undertaking what is called dynamic optimization—optimizing project investment over time. Dynamic optimization, however, requires knowledge of all future budget constraints and investment opportunities and so is not a practical methodology to apply in real project investment decisions.

The net benefit-investment ratio is very convenient to use in real-life project investment decisions. It may be used to rank projects in those instances in which, for one reason or another, sufficient funds are not available to implement all projects. It thus satisfies a frequent request of decisionmakers that projects be ranked in the order in which they should be undertaken. It is suitable for use when there is incomplete knowledge of all projects in all periods; when budget constraints will vary in magnitude in the future; and when it is very difficult or costly to redesign

projects in future periods—for example, to change the height of a dam—conditions that make it impossible to attempt dynamic optimization.

In a manner similar to that described for the benefit-cost ratio, the net benefit-investment ratio may be used to make a quick estimate of how much the investment cost could rise without making the project economically unattractive. In table 9-18, for example, we can tell by inspection that the investment cost could rise as much as 75 percent before the net benefit-investment ratio would be driven down to one [(22.43 − 12.85) ÷ 12.85 × 100 = 75; 22.43 ÷ (12.85 × 1.75) = 1.00]. By taking the reciprocal of the net benefit-investment ratio and subtracting it from 1, we can quickly tell that the net benefit could fall by almost 43 percent before the ratio would be driven down to one {[1 − (1 ÷ 1.75)] × 100 = 43; [22.43 − (22.43 × 0.43)] − 12.85 = 0.99 }. Thus, again, we have a quick means of estimating two switching values, which are discussed further in the next chapter.

Selecting among Project Alternatives

To illustrate how discounted measures of project worth can be applied to help choose among project alternatives, we return to the four hypothetical investments in pump irrigation presented at the beginning of this chapter and set out in table 9-1 to illustrate undiscounted measures of project worth. In the analysis laid out in table 9-19, we have calculated the net present worth at a 12 percent discount rate, the internal rate of return, the benefit-cost ratio at a 12 percent discount rate, and the net benefit-investment ratio at a 12 percent discount rate.

It is clear that we would reject both projects I and II at the 12 percent discount rate. We would accept project II only if our discount rate were 8 percent or lower, when it would have a net present worth of zero or greater, an internal rate of return at or above the cut-off rate, and a net benefit-investment ratio of 1 or greater. At the 12 percent discount rate we would accept *both* projects III and IV, since both have positive net present worths, internal rates of return above the cut-off rate, and benefit-cost and net benefit-investment ratios greater than 1. If, however, our investment funds were limited to some 30 million currency units (and ignoring any problem of the cash flow within year 2), we would have to choose between projects III and IV. We can see that, by increasing the discount rate, an unambiguous choice would be made. If we set the discount rate at 15 percent, we would accept only project IV, which would have a positive net present worth and an internal rate of return just above the cut-off rate. We would have just used all our investment funds, so our selection criterion would be clear. Alternatively, and more simply, we could select project IV on the basis that it has the higher net benefit-investment ratio at a 12 percent discount rate. (Because of the very simplified figures we have used for illustration, the net present worth, the internal rate of return, and the benefit-cost ratio also rank the projects in the same order as would the net benefit-investment ratio and the formal

selection criterion of raising the discount rate. This is only a coincidence. At any given discount rate, we cannot with confidence use the net present worth, or the internal rate of return, or the benefit-cost ratio as ranking measures; our criteria tell us only to accept all projects which meet the selection criteria for these three measures. The net benefit-investment ratio is the only measure of the ones we have discussed that can be used with confidence to rank directly.)

What Happened to Depreciation?

We may now consider a question that sometimes vexes people who are trying to use discounted measures of project worth.

In determining the costs used to calculate discounted measures of project worth, we have not included depreciation. When we discussed the incremental net benefit stream or cash flow, we noted that it was an undifferentiated combination of two things: return *of* capital (which would include depreciation) and returns paid for the use of capital (such as dividends, profits, and the like)—returns *to* capital. We did not subtract depreciation as a cost. Depreciation does not appear in the gross cost computation for the benefit-cost ratio. Yet net present worth determines if a project can earn *more* than some stated amount of return to capital, the internal rate of return is a measure of the interest a project can pay, and the net benefit-investment ratio determines if the project will have a net benefit greater than the investment at some stated amount of return to capital. The question is, what happened to depreciation?

The easiest way to go about illustrating what happens to depreciation in discounted measures of project worth is to compute the net present worth, the internal rate of return, the benefit-cost ratio, and the net benefit-investment ratio of a hypothetical example such as that shown in table 9-20. In this case, we are analyzing a project that does not exactly lose money, but does not make money either. In other words, its net present worth at zero discount rate is zero, its internal rate of return is zero, its benefit-cost ratio at zero rate of interest is just exactly 1, and the net benefit-investment ratio at a zero discount rate is 1.

The question we are concerned with here is, did we get our money back? The answer, obviously, is yes. We spent 1,200 thousand currency units over the five years of the project, and by the end of the fifth year we have received just exactly 1,200 thousand back. So we didn't lose any of our capital, and we recovered all of our other costs.

Did we earn anything on this project? Clearly, no. Both the net present worth and the internal rate of return of this project were simply zero, and the benefit-cost and net benefit-investment ratios had to be computed at a zero rate of interest to have them come out to 1.

Therefore, return *of* capital is realized (that is, depreciation is covered and fully accounted for) when the net present worth of the project at a zero discount rate is zero or greater, when the project earns an internal

Table 9-19. *Ranking of Four Hypothetical Pump Irrigation Projects Using N/K Ratio*
(thousands of currency units)

Year	Gross cost	Value of incremental production (gross benefit)	Incremental net benefit (cash flow)	Discount factor 12%	Present worth 12%	Present worth calculation at internal rate of return: Discount factor 0%	Present worth 0%	Rank
Project I								
1	30,000	—	−30,000	0 893	−26,790	1 000	−30,000	
2	5,000	20,000	+15,000	0 797	+11,955	1 000	+15,000	4
3	5,000	20,000	+15,000	0 712	+10,680	1 000	+15,000	
4	—	—	—	—	—	—	—	
Total	40,000	40,000	0	2 402	− 4,155	3.000	0	

Net present worth at 12 percent = −4,155,000
Internal rate of return = 0 percent
Benefit-cost ratio at 12 percent = 0 88[a]
N/K *ratio at 12 percent* = 22,635 − 26,790 = 0 84

Year	Gross cost	Value of incremental production (gross benefit)	Incremental net benefit (cash flow)	Discount factor 12%	Present worth 12%	Present worth calculation at internal rate of return: Discount factor 8%	Present worth 8%	Rank
Project II								
1	30,000	—	−30,000	0 893	−26,790	0 926	−27,780	
2	5,000	20,000	+15,000	0 797	+11,955	0 857	+12,855	3
3	5,000	20,000	+15,000	0.712	+10,680	0.794	+11,910	
4	5,000	9,100	+ 4,100	0 636	+ 2,608	0.735	+ 3,014	
Total	45,000	49,100	+ 4,100	3 038	− 1,547	3 312	− 1	

Net present worth at 12 percent = 1,547,000
Internal rate of return = 8 percent
Benefit-cost ratio at 12 percent = 0 96[a]
N/K *ratio at 12 percent* = 25,243 − 26,790 = 0.94

						Discount factor 14%	*Present worth 14%*	
Project III								
1	30,000	—	−30,000	0.893	−26,790	0.877	−26,310	
2	5,000	7,000	+ 2,000	0.797	+ 1,594	0.769	+ 1,538	2
3	5,000	19,000	+14,000	0.712	+ 9,968	0.675	+ 9,450	
4	5,000	31,000	+26,000	0.636	+16,536	0.592	+15,392	
Total	45,000	57,000	+12,000	3.038	+ 1,308	2.913	+ 70	

Net present worth at 12 percent = 1,308,000
Internal rate of return = 14 percent
Benefit-cost ratio at 12 percent = 1.03[a]
N/K *ratio at 12 percent* = 28,098 ÷ 26,790 = 1.05

						Discount factor 16%	*Present worth 16%*	
Project IV								
1	30,000	—	−30,000	0.893	−26,790	0.862	−25,860	
2	5,000	7,000	+ 2,000	0.797	+ 1,594	0.743	+ 1,486	1
3	5,000	31,000	+26,000	0.712	+18,512	0.641	+16,666	
4	5,000	19,000	+14,000	0.636	+ 8,904	0.552	+ 7,728	
Total	45,000	57,000	+12,000	3.038	+ 2,220	2.798	+ 20	

Net present worth at 12 percent = 2,220,000
Internal rate of return = 16 percent
Benefit-cost ratio at 12 percent = 1.06[a]
N/K *ratio at 12 percent* = 29,010 − 26,790 = 1.08

Source: Table 9-1.
a. The derivation of the benefit-cost ratio is not given in this table.

Table 9-20. *Treatment of Depreciation in Discounted Measures of Project Worth*
(thousands of currency units)

Year	Incremental cost			Value of incremental production (gross benefit)	Incremental net benefit (cash flow)	Discount factor 0%	Present worth 0%
	Capital items	Production	Gross				
1	1,000	0	1,000	0	−1,000	1 000	−1,000
2	—	50	50	300	+ 250	1.000	+ 250
3	—	50	50	300	+ 250	1.000	+ 250
4	—	50	50	300	+ 250	1 000	+ 250
5	—	50	50	300	+ 250	1.000	+ 250
Total	1,000	200	1,200	1,200	0	5 000	0

Net present worth at 0 percent = 0
Internal rate of return = 0 percent
Benefit-cost ratio at 0 percent = 1,200 ÷ 1,200 = 1.00
N/K *ratio at 0 percent* = 1,000 − 1,000 = 1.00

rate of return of zero or greater, and when the benefit-cost ratio or net benefit-investment ratio is 1 at a zero or greater rate of interest. We do not need to include depreciation separately as a "cost" in analyzing our project. It is automatically taken care of in the computational process. (There is another convenience—we do not need to make any decision about what depreciation schedule to use, a notoriously difficult and arbitrary choice that is essentially an accounting, not an economic, problem.)

Of course, if the net present worth at zero discount rate is less than zero, if the internal rate of return is less than zero, or if the benefit-cost ratio or the net benefit-investment ratio at zero rate of interest is less than 1, then we not only would have earned nothing, but actually would not even have recovered all our costs.

Length of the Project Period

For how long a period should the analyst carry out the economic analysis? The general rule is to choose a period of time that will be roughly comparable to the economic life of the project.

If the project requires a fairly sizable initial capital investment in one kind of asset, such as tubewells or an orchard, a convenient starting point for establishing the period of the analysis is the technical life of the major investment item. In some projects, however, the technical life of the major investment may be quite long, but the economic life of the item is expected to be much shorter because of technological obsolescence. This may be a problem in industrial projects and in some kinds of transport projects, but it is rather uncommon in agricultural projects. Even so, the analyst might expect that the economic life of a processing plant that produces frozen foods would be shorter than the technical life of the equipment, or even that the equipment for producing broiler chickens might become obsolete before it is completely worn out. In most agricultural projects, however, we do not anticipate that rapidly changing technology will make a major investment obsolete over a period of twenty to twenty-five years.

When the economic life of the project is not limited by considerations of obsolescence, and the technical life of the major investment asset extends beyond about twenty-five years, another consideration comes into play that helps to establish a reasonable economic life for the project and, hence, for the economic project analysis. At the discount rates we are talking about and the opportunity costs for capital we think exist in developing countries, any return to an investment beyond about twenty-five years will probably make no difference in project selection. As a result, few agricultural project analyses need to be carried out beyond twenty-five years. But if the technicians working on the project feel the analyst should carry out the economic analysis for a longer period because coconuts will bear for forty years or because a dam can reasonably be expected to last fifty years, then it may be easier for the analyst simply

to run the calculations through to a period that satisfies the technicians rather than to discuss the matter further. It is better to save the discussion for the difficult problems of project design and implementation.

To illustrate that extending the economic analysis beyond twenty-five years makes little difference in project selection, we may take two approaches: looking at the discount factors themselves and running an illustrative internal rate of return.

First, the discount factors. Suppose the proposed project is a large dam. We can reasonably expect the dam to last well over fifty years, even though its effectiveness after fifty years may be greatly reduced because of silting. Yet look at the effect on the present worth (and, hence, on present decisionmaking) of that distant benefit. At 14 percent, any benefit received in the fiftieth year is worth today only one-thousandth of its face value—a thousand currency units of return in fifty years is worth only one currency unit today. Beyond fifty years, this dwindles to such a minor amount that it is even difficult to find a table that gives the discount factors.

Even if we are talking about extending the period of analysis from twenty-five to fifty years, the difference these additional twenty-five years make is rather minor. Again, looking at the discount factors:

Present worth of an annuity factor for fifty years at 14 percent	7.133
Less present worth of an annuity factor for twenty-five years at 14 percent	−6.873
Present worth of an annuity factor for twenty-sixth through fiftieth years at 14 percent	0.260

Doubling the life of the project by adding twenty-five years to the analysis only increases the total present worth of the project by about one-fourth of one year's annual net benefit. Put another way, the net benefit from the twenty-sixth to the fiftieth year is worth today only about three months' worth of the same net benefit during the first year.

The calculation in table 9-21, drawn from the Lilongwe Development Program in Malawi, shows the effect on the internal economic return of extending the length of the project period. (The symbol for Malawi pounds is M£. Since this project was prepared, the currency unit of Malawi has been changed to kwachas, MK.) Doubling the assumed life of the project (and assuming no more investment) increases the economic rate of return by only 1 percent, from 13 percent to 14 percent. Given the probable error in estimating yields, prices, and rate of acceptance by farmers, this difference is meaningless.

How Far to Carry Out Computations of Discounted Measures

In agricultural projects, it is misleading to carry out the computations of discounted measures very far. The underlying estimates of the data are

Table 9-21. *Effect on Economic Rate of Return of Doubling Project Life from Twenty-five to Fifty Years, Lilongwe Development Program, Malawi*
(thousands of M£)

Year	*Incremental net benefit (cash flow)*	*Discount factor 10%*	*Present worth 10%*	*Discount factor 15%*	*Present worth 15%*
		Assuming project life of twenty-five years			
1	− 920	0.909	− 836	0.870	−800
2	− 569	0.826	− 470	0.756	−430
3	− 556	0.751	− 418	0.658	−366
4	− 492	0.683	− 336	0.572	−281
5	− 360	0.621	− 224	0.497	−179
6	− 164	0.564	− 92	0.432	− 71
7	+ 30	0.513	+ 15	0.376	+ 11
8	+ 372	0.467	+ 174	0.327	+122
9	+ 563	0.424	+ 239	0.284	+160
10	+ 650	0.386	+ 251	0.247	+161
11	+ 710	0.350	+ 248	0.215	+153
12	+ 751	0.319	+ 240	0.187	+140
13	+ 781	0.290	+ 226	0.163	+127
14–25	+ 884[a]	1.974[b]	+1,745	0.881[b]	+779
Total	+11,404	9.077	+ 762	6.465	−474
Economic rate of return = 10 + 5(762 ÷ 1,236) = 13 percent					
		Assuming project life of fifty years			
1–25[c]	+11,404	9.077	+ 762	6.465	−474
26–50	+ 884[d]	0.838[e]	+ 741	0.197[e]	+174
Total	+33,504	9.915	+1,503	6.662	−300
Economic rate of return = 10 + 5(1,503 − 1,803) = 14 percent					

M£ Malawi pounds (since this project was prepared, the currency unit in Malawi has been changed to kwachas, or MK).

Source: Adapted from World Bank, "Lilongwe Development Program," TO-610a (Washington, D.C., 1968; restricted circulation), annex 4.

a. Annual amount for years 14 through 25 inclusive. To reach column total, this amount must be included 12 times.

b. Present worth of an annuity factor for years 14 through 25 inclusive. See the subsection on "Present worth of a stream of future income" for method of computation.

c. From total line in first section of the table.

d. Annual amount for years 26 through 50 inclusive. To reach column total, this amount must be included 25 times.

e. Present worth of an annuity factor for years 26 through 50 inclusive. See the subsection on "Present worth of a stream of future income" for method of computation.

so inaccurate at best that carrying out the computations to many decimal places implies a spurious precision.

For net present worth, it is normal to report the result in the nearest thousand or million currency units, although in smaller projects the result may sometimes be given in the nearest unit.

Financial and economic rates of return are best rounded to the nearest whole percentage point. Since extremely high internal rates of return are difficult to interpret on theoretical grounds, it is better to report them simply as being very high. As a practical limit, I would suggest not giving

internal rates of return greater than 50 percent. Above that value, financial or economic rates of return may be reported as "over 50 percent."

In general, benefit-cost and net benefit-investment ratios are best rounded to the nearest hundredth of a ratio value. Thus, a benefit-cost or a net benefit-investment ratio for which the computation results in a value of 1.434 would be reported as 1.43.

To determine discounted measures of project worth at these levels of accuracy, discount factors of three decimal places are sufficient. This being so, the summary tables in appendix B may be used conveniently and with confidence to determine discounted measures of project worth and to perform most other project computations in which use of such tables is appropriate.

When the analyst includes discounted measures of project worth in a project report, it is unnecessary to show the details of the discounting computation in the summary presentations (such details may be included in an annex to the report). A notation in the main text and at the bottom of the summary tables about the net present worth, the economic or financial rate of return, the benefit-cost ratio, or the net benefit-investment ratio is enough. If how the analyst arrived at the cash flow or the gross cost and benefit is clearly presented, those who are familiar with the analytical techniques will be able to understand how the discounting computation was carried out.

If the analyst is presenting the results of a financial analysis to show a financial rate of return, the point of view assumed in the analysis must be clearly specified. The entry should read "financial rate of return to all resources engaged," "financial rate of return to equity before income taxes," "financial rate of return to the farmer's own resources," or some similar, specific statement.

Comparisons among Discounted Measures

The interrelations of the four discounted measures of project worth can be clearly specified. The internal rate of return is that discount rate which just makes the net present worth of the project equal zero and the benefit-cost ratio and net benefit-investment ratio equal 1.

Taking the opportunity cost of capital as the discount or cut-off rate, from any array of possible project alternatives all four discounted measures of project worth will identify exactly the same group of projects for implementation, although (as discussed above) mutually exclusive projects will have to be subjected to further tests if the internal rate of return, benefit-cost ratio, or net benefit-investment ratio criteria are used. For net present worth, internal rate of return, and benefit-cost ratio, the formal criterion is to accept all projects that meet the test—that is, that have a positive net present worth at the opportunity cost of capital, have an internal rate of return above the opportunity cost of capital, or have a benefit-cost ratio of 1 or greater at the opportunity cost of capital. For the net benefit-investment ratio, the formal selection criterion is to accept

projects discounted at the opportunity cost of capital in order, beginning with the largest ratio value and continuing until all investment funds have been exhausted.

Which discounted measure the analyst chooses will depend on the practice in the country in which he is working or on the preference of the financing agency that will be approached to lend for the project. Many project analysts prefer the net present worth criterion for its simplicity, unambiguous quality, and straightforward way of selecting among mutually exclusive projects. They reject the argument that the necessity to establish a reasonable estimate of the opportunity cost of capital before the net present worth can be calculated is a valid objection to use of this measure. They argue that in any event a nation should face up to this task. Some analysts prefer the internal rate of return criterion because it is more easily understood by those not familiar with the discounted measures. The internal rate of return can readily be explained as the maximum rate of interest that a project could pay if all resources were borrowed; it thus can be explained as a measure of the return on the resources engaged in the project. The World Bank has tended to use the internal rate of return as its principal discounted measure because the internal rate of return avoids making a close comparison of the opportunity cost of capital in the Bank's various member countries or setting a worldwide opportunity cost of capital. The net benefit-investment ratio provides a means of ranking independent (not mutually exclusive) projects. As noted earlier, the benefit-cost criterion is infrequently used in developing countries.

In virtually all actual project analyses, the practice is to work out a project and to make the best estimate of the results expressed in one of the discounted measures. Then the project may be selected if it has a net present worth of zero or greater, an internal rate of return equal to or above the cut-off rate, or a benefit-cost ratio or a net benefit-investment ratio of 1 or greater. The criteria, thus, are used on a "go–no-go" basis. Many administrators, however, intuitively tend to rank projects on the basis of the internal rate of return or the benefit-cost ratio. We have noted that, although in a very rough sense projects can be ranked in this manner, it is better not to do this, for it can lead to an erroneous investment decision. It is preferable to use the net benefit-investment ratio to rank projects. The fact of the matter is that ranking is generally unnecessary and so is much better avoided. Rarely can a nation afford to have a "shelf" of fully prepared projects ready to implement and in need of ranking. The demands of economic development are too urgent and the costs of preparing projects too great. Choice among projects that meet the formal criteria of acceptance is related not to the rank of the projects by a discounted measure of worth but on other, noneconomic grounds—including the ability to implement the projects. Given these realities, the ranking issue is a false one. It is sufficient for economic analysis to establish a realistic opportunity cost of capital and accept for implementation those projects which meet such other criteria as regional and sectoral balance, effect on low-income farmers, or administrative feasi-

Table 9-22. *Comparison of Discounted Measures of Project Worth*

Item	*Net present worth (NPW)*	*Internal rate of return (IRR)*	*Benefit-cost (B/C) ratio*	*Net benefit-investment (N/K) ratio*
Selection criterion	Accept all independent projects with NPW of zero or greater when discounted at opportunity cost of capital (see "Mutually exclusive alternatives," below)	Accept all independent projects with IRR equal to or greater than opportunity cost of capital	Accept all independent projects with B/C ratio of 1 or greater when discounted at opportunity cost of capital	Accept all independent projects with N/K ratio of 1 or greater when discounted at opportunity cost of capital in order of ratio value until available investment funds are exhausted
Ranking	Gives no ranking for order of implementation	May give incorrect ranking among independent projects	May give incorrect ranking among independent projects	May be used to rank independent projects
Mutually exclusive alternatives	Accept alternative with largest NPW when discounted at opportunity cost of capital (NPW is the preferred selection criterion for mutually exclusive alternatives)	Cannot be used directly; must discount differences between incremental net benefit flows of mutually exclusive alternative projects	Cannot be used directly	Cannot be used directly
Discount rate	Must determine a suitable discount rate, generally the opportunity cost of capital	Determined internally; must determine opportunity cost of capital to use as a cut-off rate	Must determine a suitable discount rate, generally the opportunity cost of capital	Must determine a suitable discount rate, generally the opportunity cost of capital

bility and which also are economically attractive as indicated by one of the discounted measures of project worth.

In summary, and for easy reference, some of the contrasts among the net present worth, the internal rate of return, the benefit-cost ratio, and the net benefit-investment ratio are compared in table 9-22.

Appendix. Mathematical Formulations of Discounted Measures of Project Worth

The formal mathematical statements of the discounted measures of project worth discussed in this chapter are given below.

Net present worth:

$$\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}.$$

Internal rate of return:

The discount rate i such that

$$\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} = 0.$$

Benefit-cost ratio:

$$\frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}.$$

Net benefit-investment (N/K) ratio:

$$\frac{\sum_{t=1}^{t=n} \frac{N_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{K_t}{(1+i)^t}}.$$

In the four mathematical formulations,

B_t = benefit in each year
C_t = cost in each year
N_t = incremental net benefit in each year after stream has turned positive
K_t = incremental net benefit in initial years when stream is negative
$t = 1, 2, \ldots, n$
n = number of years
i = interest (discount) rate.

10

Applying Discounted Measures of Project Worth

WHEN APPLYING discounted measures of project worth in financial and economic analysis of proposed projects, the analyst may encounter some practical questions about their use. I will address several of these questions in this chapter.

Sensitivity Analysis (Treatment of Uncertainty)

One of the real advantages of careful economic and financial project analysis is that it may be used to test what happens to the earning capacity of the project if events differ from guesses made about them in planning. How sensitive is a project's net present worth at financial prices and economic values, or its financial and economic rate of return or net benefit-investment ratio, to increased construction costs? To an extension of the implementation period? To a fall in prices? Reworking an analysis to see what happens under these changed circumstances is called sensitivity analysis. It is one means of drawing attention to a central reality of project analysis: projections are inevitably subject to a high degree of uncertainty about what will actually happen.

Facing page: Plucking tea in Java, Indonesia.

All projects should be subjected to sensitivity analysis. In agriculture, projects are sensitive to change in four principal areas. These, and the technique of sensitivity analysis, are considered below.

Price

Probably every agricultural project should be examined to see what happens if the assumptions about the sale price of the project's product prove wrong. For this the analyst can make alternative assumptions about future prices and see how these affect the net present worth, the financial and economic rates of return, or the net benefit-investment ratio (often abbreviated as N/K ratio).

Testing a project to see what will happen to the measures of project worth when different shadow prices are assumed is also a kind of sensitivity analysis. The analyst could examine a project to see the effect of using the market wage for labor or a shadow price, the official exchange rate or a foreign exchange premium, and so forth. Because of the difficulties in establishing shadow prices, if the project turns out to be relatively insensitive to shadow pricing, it may be better to present the analysis in market prices and to note that the net present worth, the economic rate of return, and the net benefit-investment ratio are relatively insensitive to shadow prices.

Delay in implementation

Delay in implementation affects most agricultural projects. Farmers may fail to adopt new practices as rapidly as anticipated, or they may find it harder to master new techniques than was thought. Other technical difficulties may be underestimated. There may be delays in ordering and receiving new equipment. Unavoidable administrative problems and requirements may delay the project. Testing to determine the effects of delay on the net present worth, the financial and economic rates of return, and the net benefit-investment ratio of a proposed agricultural investment is an important part of the sensitivity analysis.

Cost overrun

Almost every agricultural project should be tested for sensitivity to cost overrun. Projects tend to be very sensitive to cost overrun—especially for construction—because so often the costs are incurred early in the project when they weigh heavily in the discounting process and are for facilities that must be complete before any benefit can be realized. A project that has a quite attractive return if the estimated cost is in fact realized may be only marginally acceptable or unacceptable if costs early in the implementation phase rise significantly.

Cost estimates often are not very firm—one more reason projects should be tested for cost overrun. In many project analyses there is considerable uncertainty about the prices that actually will have to be

paid for supplies and equipment. There is a tendency, too, for technicians and project analysts to make their cost estimates on the basis of overoptimistic implementation schedules and assumptions about prices for project inputs.

It is projects with substantial construction components that must be most carefully tested for cost overrun. We noted under "Accuracy of Agricultural Project Analyses. Implementation experience" in chapter 1 that it is large-scale groundwater projects, with their substantial construction element that must be completed before any water can flow, that have the worst record for cost overrun among the principal kinds of projects assisted by World Bank financing. Characteristically, these projects are very sensitive to cost overrun. Agricultural projects are less likely to be as sensitive to production costs that arise later in the life of the project, although in these instances, again, overruns for production costs may make an otherwise quite good project much less attractive.

A test that shows a project to be very sensitive to cost overrun may signal to those who must make investment decisions that it is important to have firm cost estimates before proceeding with the final decision, even if obtaining firm estimates may mean a delay in the start of project implementation. If a project is particularly sensitive to cost overrun, it is also a signal to the project manager and those to whom he reports that it is important to contain costs if the project is to make its expected contribution to increasing national income.

Yield

The analyst may wish to test a proposed project for its sensitivity to errors in estimated yield. There is a tendency in agricultural projects to be optimistic about potential yields, especially when a new cropping pattern is being proposed and the agronomic information is based mainly on experimental trials. A test to determine how sensitive the project's net present worth, financial and economic rates of return, or net benefit-investment ratio are to lower yields not only may provide information useful in deciding whether to implement the project, but also may emphasize the need to ensure sufficient extension services if the project is to be as high-yielding as could reasonably be expected.

Technique of sensitivity analysis

The technique of sensitivity analysis is not complicated. The analyst simply calculates the measure of project worth over again using the new estimates for one or another element of cost or return. The technique is illustrated in tables 10-1 through 10-3 for the Jatiluhur Irrigation Project in Indonesia. In this case, the most probable outcome of the project was listed (table 10-1), and then the project was tested for its sensitivity to a 30 percent cost overrun (table 10-2) and to a 10 percent fall in the price of rice (table 10-3). In these as in earlier tables of this kind, a convention has been adopted that lists the *annual* amount for each year when that

Table 10-1. *Sensitivity Analysis, Jatiluhur Irrigation Project, Indonesia: Most Probable Outcome*
(thousand millions of Rp)

Year	*Incremental cost*	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 20%*	*Present worth 20%*	*Discount factor 25%*	*Present worth 25%*
1	0.5	—	− 0.5	0.893	−0 45	0.833	−0.42	0.800	−0.40
2	2.1	0.4	− 1.7	0.797	−1.35	0.694	−1.18	0.640	−1.09
3	3.7	0.8	− 2.9	0 712	−2 06	0.579	−1.68	0.512	−1.48
4	3 7	1 4	− 2.3	0.636	+1.46	0.482	−1.11	0.410	−0.94
5	2.0	2.1	+ 0.1	0.567	+0.06	0.402	+0.04	0.328	+0.03
6	0 5	2.5	+ 2.0	0.507	+1.01	0.335	+0.67	0.262	+0 52
7–30	0.5[b]	2.9[b]	+ 2.4[b]	3.944	+9 47	1.653	+3 97	1 044	+2.51
Total	24.5	76 8	+52.3	8.056	+8.14	4 978	+0.29	3.996	−0.85

Net present worth at 12 percent = Rp+8.14
Economic rate of return = 20 + 5(0.29 − 1.14) = 20 + 5(0.25) = 21 percent
Net benefit-investment (N/K) ratio at 12 percent = Rp12.00 − Rp3.86 = 3 11

Rp Indonesian rupiahs.

Source: Adapted from World Bank, "Djatiluhur Irrigation Project—Indonesia," PA-37 (Washington, D.C., 1970; restricted circulation), p. 26 and annex 10, p. 1. Since this report was published, a spelling reform has changed the spelling of the project area to Jatiluhur.

a. Assumes only an improvement in water control; that is, no accompanying increase in the use of modern inputs

b. Annual amount for years 7 through 30 inclusive To reach column total, this amount must be included 24 times. This same convention is adopted wherever it is relevant for all tables in this chapter.

Table 10-2. *Sensitivity Analysis, Jatiluhur Project: Assuming 30 Percent Cost Overrun*
(thousand millions of Rp)

Year	*Incremental cost*	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 15%*	*Present worth 15%*	*Discount factor 20%*	*Present worth 20%*
1	0.6	—	− 0.6	0.893	−0.54	0.870	−0.52	0.833	−0.50
2	2.7	0.4	− 2.3	0.797	−1.83	0.756	−1.74	0.694	−1.60
3	4.8	0.8	− 4.0	0.712	−2.85	0.658	−2 63	0.579	−2.32
4	4.8	1.4	− 3.4	0.636	−2.16	0.572	−1.94	0.482	−1.64
5	2.6	2.1	− 0.5	0.567	−0.28	0.497	−0.25	0.402	−0.20
6	0.6	2.5	+ 1.9	0.507	+0 96	0.432	+0.82	0.335	+0.64
7–30	0.6	2.9	+ 2.3	3.944	+9.07	2.782	+6.40	1.653	+3.80
Total	30.5	76.8	+46.3	8.056	+2.37	6.567	+0.14	4.978	−1.82

Net present worth at 12 percent = Rp + 2.37
Economic rate of return = 15 + 5(0.14 − 1.96) = 15 + 5(0.07) = 15 percent
N/K *ratio at 12 percent* = Rp10 03 ÷ Rp7.66 = 1.31

Source: Same as table 10-1.

a. Assumes only an improvement in water control; that is, no accompanying increase in the use of modern inputs.

Table 10-3. *Sensitivity Analysis, Jatiluhur Project: Assuming 10 Percent Lower Price of Rice*
(thousand millions of Rp)

Year	*Incremental cost*	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 15%*	*Present worth 15%*	*Discount factor 19%*[b]	*Present worth 19%*
1	0.5	—	− 0.5	0.893	−0.45	0.870	−0.44	0.840	−0.42
2	2 1	0.4	− 1.7	0.797	−1.35	0.756	−1.29	0 706	−1.20
3	3.7	0.7	− 3.0	0 712	−2.14	0.658	−1 97	0.593	−1.78
4	3.7	1.3	− 2.4	0 636	−1.53	0.572	−1.37	0.499	−1.20
5	2.0	1.9	− 0 1	0.567	−0.06	0.497	−0.05	0.419	−0.04
6	0.5	2.2	+ 1.7	0.507	+0.86	0 432	+0.73	0.352	+0.60
7–30	0.5	2.6	+ 2.1	3.944	+8.28	2.782	+5 84	1.825	+3.83
Total	24.5	68.9	+44.4	8.056	+3.61	6 567	+1.45	5.234	−0.21

Net present worth at 12 percent = Rp+3.61
Economic rate of return = 15 + 4(1.45 ÷ 1.66) = 15 + 4(0.87) = 18 percent
N/K *ratio at 12 percent* = Rp9.14 − Rp5.53 = 1 65

Source: Same as table 10-1.

a Assumes only an improvement in water control, that is, no accompanying increase in the use of modern inputs.

b. For a discussion of the interpolation interval, see the subsection on "Choosing the discount rate," chapter 9.

amount is constant over several years. Thus, to reach the total incremental net benefit in table 10-1 of Rp52.3 thousand million, the annual amount of Rp2.4 thousand million must be included 24 times [$-0.5 - 1.7 - 2.9 - 2.3 + 0.1 + 2.0 + 24(2.4) = 52.3$]. (The symbol for Indonesian rupiahs is Rp.)

Note what happened to the wealth-generating potential of the project under this sensitivity test. When a 30 percent cost overrun was assumed (table 10-2), the net present worth, assuming a 12 percent opportunity cost of capital, fell 71 percent, from Rp8.14 thousand million to Rp2.37 thousand million [$(8.14 - 2.37) \div 8.14 \times 100 = 71$]; the economic rate of return fell by 29 percent, from 21 percent to 15 percent [$(21 - 15) \div 21 \times 100 = 29$]; and the net benefit-investment ratio, also assuming a 12 percent opportunity cost of capital, fell by a factor of 2.37 ($3.11 \div 1.31 = 2.37$). When a 10 percent reduction in the price of rice was assumed (table 10-3), the net present worth fell 56 percent, from Rp8.14 thousand million to Rp3.61 thousand million [$(8.14 - 3.61) \div 8.14 \times 100 = 56$]; the economic rate of return fell by 14 percent, from 21 percent to 18 percent [$(21 - 18) \div 21 \times 100 = 14$]; and the net benefit-investment ratio was cut in half [$(3.11 - 1.65) \div 3.11 = 0.47$]. With these possible outcomes known, whoever must make the project decision may now ask whether it is worth running the risk of that large a drop in the worth of the project, given how likely the cost overrun (or the lower price) will be.

The higher the expected yield, the more sensitive the project. Projects will also be more sensitive to earlier items than to later ones—a direct consequence of the time value of money. Thus, in general, projects tend to be more sensitive to cost overruns that occur early in the project life than to price changes that occur later. Usually, too, a given proportionate change in a major cost or return item will have a more than proportionate effect on the measures of project worth. In the Jatiluhur project in tables 10-1 through 10-3, for example, a 10 percent fall in the price of rice reduced the net present worth by 56 percent, the economic rate of return by 14 percent, and the net benefit-investment ratio by half. No general rule about these relations can be cited. Each sensitivity analysis must be undertaken separately to estimate the effect of a change in assumptions on the worth of the project, and then a judgment must be made about how likely that change will be.

Sensitivity analysis not only has important implications for investment decisions, it also has very important implications for project management. Suppose a project turns out to be particularly sensitive to delay. If senior decisionmakers are aware of how sensitive the project is and how much delay will cost the nation in lost opportunities to generate wealth, these decisionmakers may be willing to cut "red tape"—to ensure that there will not be unnecessary delays in processing financing and other requests from the project and that prompt cooperation will be forthcoming from the agencies that must support the project. Or, it may be decided that the likelihood of delay is so substantial—no matter how effective the project manager is—that it is better to redesign the project to make it more manageable and to permit postponing some costs if

Table 10-4. *Switching Values, Cotton Processing and Marketing Project, Kenya: Most Probable Outcome*
(thousands of KSh)

Fiscal year	*Incremental cost*	*Incremental benefit*	*Incremental net benefit (cash flow)*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 20%*	*Present worth 20%*	*Discount factor 25%*	*Present worth 25%*
1982	93,004	5,761	− 87,243	0.893	− 77,908	0.833	−72,673	0.800	−69,794
1983	101,140	22,833	− 78,307	0.797	− 62,411	0.694	−54,345	0.640	−50,116
1984	98,049	46,177	− 51,872	0.712	− 36,933	0.579	−30,034	0.512	−26,558
1985	56,135	71,119	+ 14,984	0.636	+ 9,530	0 482	+ 7,222	0.410	+ 6,143
1986	25,385	80,385	+ 55,000	0.567	+ 31,185	0.402	+22,110	0.328	+18,040
1987	31,804	91,348	+ 59,544	0 507	+ 30,189	0.335	+19,947	0.262	+15,601
1988	24,308	94,178	+ 69,870	0.452	+ 31,581	0.279	+19,494	0.210	+14,673
1989	24,032	96,915	+ 72,883	0.404	+ 29,445	0.233	+16,982	0.168	+12,244
1990	23,962	98,097	+ 74,135	0.361	+ 26,763	0.194	+14,382	0.134	+ 9,934
1991	21,314	98,097	+ 76,783	0 322	+ 24,724	0 162	+12,439	0.107	+ 8,216
1992	26,145	98,097	+ 71,952	0.287	+ 20,650	0.135	+ 9,714	0.086	+ 6,188
1993	22,476	98,097	+ 75,621	0.257	+ 19,435	0.112	+ 8,470	0.069	+ 5,218
1994	23,289	98,097	+ 74,808	0.229	+ 17,131	0.093	+ 6,957	0.055	+ 4,114
1995	24,641	98,097	+ 73,456	0.205	+ 15,058	0 078	+ 5,730	0.044	+ 3,232
1996	18,797	98,097	+ 79,300	0.183	+ 14,512	0 065	+ 5,155	0.035	+ 2,776
1997	26,164	98,097	+ 71,933	0.163	+ 11,725	0.054	+ 3,884	0.028	+ 2,014
1998	23,622	98,097	+ 74,475	0.146	+ 10,873	0.045	+ 3,351	0.023	+ 1,713
1999	24,641	98,097	+ 73,456	0 130	+ 9,549	0.038	+ 2,791	0.018	+ 1,322
2000	22,124	98,097	+ 75,973	0.116	+ 8,813	0.031	+ 2,355	0.014	+ 1,064
2001	19,030	98,097	+ 79,067	0.104	+ 8,223	0.026	+ 2,056	0.012	+ 949
Total	730,062	1,685,880	+955,818	7.471	+142,134	4.870	+ 5,987	3.955	−33,027

Net present worth at 12 percent = KSh+142,134

Economic rate of return = 20 + 5(5,987 − 5,987 + 33,027) = 20 + 5(0.15) = 21 percent

N/K *ratio* = 319,386 ÷ 177,252 = 1.80

KSh Kenyan shillings.

Source: Adapted from World Bank, "Kenya, Cotton Processing and Marketing Project, Staff Appraisal Report," 3355-KE (Washington, D.C., 1981, restricted circulation), pp. 50 and 62.

necessary so that the project is less sensitive to delay. This may be desirable even though redesigning the project may somewhat reduce the overall net present worth, rate of return, or net benefit-investment ratio.

Sensitivity analysis is a straightforward (but often quite sufficient) means of analyzing the effects of risk and uncertainty in project analysis. A much more elaborate technique of risk analysis using probability theory and requiring use of a computer is outlined by Reutlinger (1970) and Pouliquen (1970). That approach is generally called "probability analysis." In contrast, the techniques we have been discussing (including sensitivity analysis) are usually called "most probable outcome analysis."

Switching Value

A variation of sensitivity analysis is the "switching value." In straightforward sensitivity analysis we choose an amount by which to change an important element in the project analysis and then determine the impact of that change on the attractiveness of the project. In contrast, when we calculate a switching value we ask how much such an element would have to change in an unfavorable direction before the project would no longer meet the minimum level of acceptability as indicated by one of the measures of project worth. Then those responsible for determining whether to proceed with the project can ask themselves how likely they feel it is that there will be a change of that magnitude.

We may illustrate computation of the switching value with an illustration taken from the Kenya Cotton Processing and Marketing Project. The project provides for improved purchasing and transport of seed cotton and for better ginning facilities. The opportunity cost of capital in Kenya at the time of the analysis was estimated to be 12 percent.

The most probable outcome estimate, laid out in table 10-4, shows that the project would have a net present worth of KSh + 142,134 at a 12 percent opportunity cost of capital, an economic rate of return of 21 percent, and a net benefit-investment ratio of 1.80 at the opportunity cost of capital. (The symbol for Kenyan shillings is KSh.)

One switching-value test the analyst undertook was to determine by what proportion the benefit would have to be reduced before the net present worth would fall to zero—the zero value, of course, would make the economic rate of return exactly 12 percent and the net benefit-investment ratio exactly 1. The computation is laid out in table 10-5. The analyst determined the net present worth at various assumed levels of benefit shortfall. At a 25 percent shortfall, the net present worth at a 12 percent opportunity cost of capital is KSh + 11,985. At a 30 percent shortfall, however, the project has a negative net present worth of KSh − 14,044. To determine the shortfall that would make the net present worth just equal zero, the analyst interpolated between the positive net present worth at 25 percent and the negative net present worth at 30 percent in a manner analogous to the interpolation done to determine the

Table 10-5. *Switching Values, Kenya Cotton Project: Assuming Benefit Shortfall*
(thousands of KSh)

	Assuming 25% shortfall in benefit			*Assuming 30% shortfall in benefit*			*Assuming 27% shortfall in benefit*		
Fiscal year	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*[b]	*Present worth 12%*	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*[b]	*Present worth 12%*	*Incremental benefit*[a]	*Net benefit (cash flow)*[b]	*Present worth 12%*
1982	4,321	− 88,683	−79,194	4,033	− 88,971	−79,451	4,206	− 88,798	−79,297
1983	17,125	− 84,015	−66,960	15,983	− 85,157	−67,870	16,668	− 84,472	−67,324
1984	34,633	− 63,416	−45,152	32,324	− 65,725	−46,796	33,709	− 64,340	−45,810
1985	53,339	− 2,796	− 1,778	49,783	− 6,352	− 4,040	51,917	− 4,218	− 2,683
1986	60,289	+ 34,904	+19,791	56,270	+ 30,885	+17,512	58,681	+ 33,296	+18,879
1987	68,511	+ 36,707	+18,610	63,944	+ 32,140	+16,295	66,684	+ 34,880	+17,684
1988	70,634	+ 46,326	+20,939	65,925	+ 41,617	+18,811	68,750	+ 44,442	+20,088
1989	72,686	+ 48,654	+19,656	67,841	+ 43,809	+17,699	70,748	+ 46,716	+18,873
1990	73,573	+ 49,611	+17,910	68,668	+ 44,706	+16,139	71,611	+ 47,649	+17,201
1991	73,573	+ 52,259	+16,827	68,668	+ 47,354	+15,248	71,611	+ 50,297	+16,196
1992	73,573	+ 47,428	+13,612	68,668	+ 42,523	+12,204	71,611	+ 45,466	+13,049
1993	73,573	+ 51,097	+13,132	68,668	+ 46,192	+11,871	71,611	+ 49,135	+12,628
1994	73,573	+ 50,284	+11,515	68,668	+ 45,379	+10,392	71,611	+ 48,322	+11,066
1995	73,573	+ 48,932	+10,031	68,668	+ 44,027	+ 9,026	71,611	+ 46,970	+ 9,629
1996	73,573	+ 54,776	+10,024	68,668	+ 49,871	+ 9,126	71,611	+ 52,814	+ 9,665
1997	73,573	+ 47,409	+ 7,728	68,668	+ 42,504	+ 6,928	71,611	+ 45,447	+ 7,408
1998	73,573	+ 49,951	+ 7,293	68,668	+ 45,046	+ 6,577	71,611	+ 47,989	+ 7,006
1999	73,573	+ 48,932	+ 6,361	68,668	+ 44,027	+ 5,724	71,611	+ 46,970	+ 6,106
2000	73,573	+ 51,449	+ 5,968	68,668	+ 46,544	+ 5,399	71,611	+ 49,487	+ 5,740
2001	73,573	+ 54,543	+ 5,672	68,668	+ 49,638	+ 5,162	71,611	+ 52,581	+ 5,468
Total	1,264,414	+534,352	+11,985	1,180,119	+450,057	−14,044	1,230,695	+500,633	+ 1,572

Proportionate fall that will make net present worth equal zero at 12 percent opportunity cost of capital
= 25 + 5[11,985 ÷ (11,985 + 14,044)] = 25 + 5(0.46) = 27 percent

Source: Same as table 10-4.

a. Most probable incremental benefit in table 10-4 reduced by appropriate proportion.

b. Most probable incremental cost from table 10-4 less incremental benefit here.

c. For a discussion of interpolation methodology, see the subsection on "Computing the internal rate of return" in chapter 9.

internal rate of return (see the subsection on "Computing the internal rate of return" in chapter 9). The computation is given at the bottom of table 10-5; it shows that the net present worth equals zero at 27 percent, rounded to the nearest whole percentage point. To verify, the net present worth is recomputed assuming a 27 percent benefit shortfall, and this gives a net present value of KSh + 1,572, not quite zero because the shortfall is rounded to the nearest whole percentage point. The analyst, thus, was able to note that "the project would have to suffer a shortfall in benefits by more than one-fourth (27 percent) before the rate of return fell to the opportunity cost of capital."

Another switching value determined for the Kenya project was to find the maximum benefit delay before the net present worth of the project would fall to zero. The computation is laid out in table 10-6. The analyst computed the net present worth assuming the benefit to be delayed by one, two, and three years. When the benefit is delayed by two years, the net present worth at a 12 percent opportunity cost of capital is KSh + 19,375, so the project would still be acceptable. If the benefit were to be delayed for three years, however, the net present worth would become negative, with a value of KSh − 32,327, and the project would not be acceptable if judged solely on economic grounds. The analyst was thus able to report that "benefits would have to be lagged by more than two years without lagging costs at all before the rate of return would fall below 12 percent."

Choosing among Mutually Exclusive Alternatives

Quite often in project design, and not infrequently in evaluating complete projects, analysts are faced with having to choose among mutually exclusive alternatives—project design options or whole projects of a nature that if one is chosen the other cannot be undertaken. This can apply to such cases as development of surface irrigation and not tubewell irrigation, river development upstream rather than downstream, and plants in alternative locations but serving the same limited market. It can also apply to such design issues as the choice among different scales for projects in which one size precludes implementing a similar project of another size, the time phasing of what is essentially the same project, the different designs for project components, or the purposes of a multipurpose project. The need to compare mutually exclusive design options is one of the principal reasons to apply economic analysis early in the project cycle.

The preferred discounted measure of project worth for choosing among mutually exclusive projects or project options is the net present worth. Direct comparison of the internal rates of return, the benefit-cost ratios, or the net benefit-investment ratios can lead to an incorrect investment decision. This is so because undertaking a small, high-paying project may preclude generating more wealth through a moderately remunerative but larger alternative.

Table 10-6. *Switching Values, Kenya Cotton Project: Assuming Benefit Delay*
(thousands of KSh)

		Most probable outcome			*Benefit delayed 2 years*			*Benefit delayed 3 years*		
Fiscal year	*Incremental cost*	*Incremental benefit*	*Incremental net benefit (cash flow)*	*Present worth 12%*	*Incremental benefit*	*Incremental net benefit (cash flow)*	*Present worth 12%*	*Incremental benefit*	*Incremental net benefit (cash flow)*	*Present worth 12%*
1982	93,004	5,761	− 87,243	− 77,908	—	− 93,004	−83,053	—	− 93,004	−83,053
1983	101,140	22,833	− 78,307	− 62,411	—	−101,140	−80,609	—	−101,140	−80,609
1984	98,049	46,177	− 51,872	− 36,933	5,761	− 92,288	−65,709	—	− 98,049	−69,811
1985	56,135	71,119	+ 14,984	+ 9,530	22,833	− 33,302	−21,180	5,761	− 50,374	−32,038
1986	25,385	80,385	+ 55,000	+ 31,185	46,177	+ 20,792	+11,789	22,833	− 2,552	− 1,447
1987	31,804	91,348	+ 59,544	+ 30,189	71,119	+ 39,315	+19,933	46,177	+ 14,373	+ 7,287
1988	24,308	94,178	+ 69,870	+ 31,581	80,385	+ 56,077	+25,347	71,119	+ 46,811	+21,159
1989	24,032	96,915	+ 72,883	+ 29,445	91,348	+ 67,316	+27,196	80,385	+ 56,353	+22,767
1990	23,962	98,097	+ 74,135	+ 26,763	94,178	+ 70,216	+25,348	91,348	+ 67,386	+24,326
1991	21,314	98,097	+ 76,783	+ 24,724	96,915	+ 75,601	+24,344	94,178	+ 72,864	+23,462
1992	26,145	98,097	+ 71,952	+ 20,650	98,097	+ 71,952	+20,650	96,915	+ 70,770	+20,311
1993	22,476	98,097	+ 75,621	+ 19,435	98,097	+ 75,621	+19,435	98,097	+ 75,621	+19,435
1994	23,289	98,097	+ 74,808	+ 17,131	98,097	+ 74,808	+17,131	98,097	+ 74,808	+17,131
1995	24,641	98,097	+ 73,456	+ 15,058	98,097	+ 73,456	+15,058	98,097	+ 73,456	+15,058
1996	18,797	98,097	+ 79,300	+ 14,512	98,097	+ 79,300	+14,512	98,097	+ 79,300	+14,512
1997	26,164	98,097	+ 71,933	+ 11,725	98,097	+ 71,933	+11,725	98,097	+ 71,933	+11,725
1998	23,622	98,097	+ 74,475	+ 10,873	98,097	+ 74,475	+10,873	98,097	+ 74,475	+10,873
1999	24,641	98,097	+ 73,456	+ 9,549	98,097	+ 73,456	+ 9,549	98,097	+ 73,456	+ 9,549
2000	22,124	98,097	+ 75,973	+ 8,813	98,097	+ 75,973	+ 8,813	98,097	+ 75,973	+ 8,813
2001	19,030	98,097	+ 79,067	+ 8,223	98,097	+ 79,067	+ 8,223	98,097	+ 79,067	+ 8,223
Total	730,062	1,685,880	+955,818	+142,134	1,489,686	+759,624	+19,375	1,391,589	+661,527	−32,327

Net present worth at 12 percent assuming benefit delayed 2 years = KSh + 19,375
Net present worth at 12 percent assuming benefit delayed 3 years = KSh − 32,327

Source: Same as table 10-4.

Sometimes what may at first be posed as a pair of mutually exclusive projects can, instead, be seen as successive phases of development. If a small project can be expanded by phases to become a larger alternative, no analytical problem is posed. To implement a small, first-phase project does not preempt a larger, phase-two project; both phases can be undertaken, with each phase judged by any of the measures of project worth.

Although net present worth is the preferred criterion for choosing among mutually exclusive alternatives, it is possible to manipulate the internal rate of return to use it to choose among mutually exclusive alternatives. The net benefit-investment ratio can be used to rank mutually exclusive projects only when the ratios of all projects in the investment program are known; therefore it is not a practical measure to use for this purpose.

To use the internal rate of return to choose between two mutually exclusive alternatives, the cash flow of the smaller alternative is subtracted year by year from the cash flow of the larger alternative. This stream of differences is then discounted to determine the internal rate of return of the stream. This is the financial or economic rate of return to the additional resources necessary to implement the larger alternative as opposed to the smaller one. (Students of economics will recognize that we are, in effect, finding the marginal return for the marginal cost incurred.) How this method is applied will be illustrated in the course of our discussion of the kinds of mutually exclusive projects, below.

When there are several mutually exclusive alternatives, determining the net present worth of each enables us to choose directly the best among them. In contrast, discounting the differences between cash flows of alternatives can only be applied to select between a single pair of alternatives. To use the internal rate of return criterion when there are more than two alternatives, one can proceed by determining the rate of return to the stream of the differences between any pair of alternatives. If the return is above the cut-off rate, the larger alternative is selected; if the return is below, the smaller is selected. The procedure is then repeated by testing the alternative chosen against another alternative, the better of this second pair is selected, and so forth in a kind of elimination tournament until all alternatives have been tested and the best identified.

We will take up five instances of mutually exclusive alternatives:

1. The most general case is where we have entirely different alternative projects that are mutually exclusive—say, a choice between a small irrigation project that preempts a site and a larger one using the same site.
2. We will discuss the scale of a project as a variation of mutually exclusive alternatives, viewing a large project as a mutually exclusive alternative to a small version of the same project.
3. Another instance is the special case of timing—whether it would be better to begin a project now or later. In effect, postponing a project is a mutually exclusive alternative to undertaking it immediately.
4. Yet another special case involves the choice of alternative tech-

Table 10-7. *Measures of Project Worth of Alternative Irrigation Schemes: Small-scale Alternative*
(thousands of currency units)

Project year	*Gross cost*	*Discount factor 12%*	*Present worth 12%*	*Gross benefit*	*Present worth 12%*	*Incremental net benefit (cash flow)*	*Present worth 12%*	*Discount factor 25%*	*Present worth 25%*	*Discount factor 30%*	*Present worth 30%*
1	500 0	0.893	446 5	—	—	− 500.0	−446.5	0.800	−400.0	0.769	−384.5
2	5.0	0.797	4.0	140 0	111.6	+ 135.0	+107.6	0.640	+ 86.4	0.592	+ 79.9
3	5 0	0.712	3.6	140.0	99 7	+ 135.0	+ 96.1	0 512	+ 69.1	0.455	+ 61.4
4	5.0	0 636	3.2	140.0	89 0	+ 135.0	+ 85.9	0.410	+ 55.4	0.350	+ 47.2
5	5.0	0.567	2 8	140.0	79.4	+ 135.0	+ 76.5	0.328	+ 44.3	0.269	+ 36.3
6-20	5 0	3 864	19.3	140.0	541.0	+ 135.0	+521.6	1.265	+170.8	0.880	+118 8
Total	595.0	7.469	479.4	2,660.0	920 7	+2,065.0	+441.2	3 955	+ 26.0	3.315	− 40.9

Net present worth at 12 percent = +441 2

Economic rate of return = 25 + 5(26.0 − 66.9) = 25 + 5(0.39) = 27 percent

N/K *ratio at 12 percent* = 887.7 − 446.5 = 1.99

nologies, in which selection of one technology rules out its alternative.

5. The final case is that of additional purposes in multipurpose projects—the river basin project to control floods and generate hydropower that also includes an irrigation purpose is a mutually exclusive alternative to the same project without the irrigation purpose.

Entirely different projects

Occasionally in agriculture we may be faced with the choice between two mutually exclusive alternative projects of an entirely different nature, one small and high-yielding and the other large but low-yielding. At a given location we may have a choice either of constructing a small irrigation project that is limited to the best land and uses rather simple equipment or of building a considerably larger project that involves a more extensive area and more costly, complicated engineering works. If the small scheme is built, it preempts the site so that the larger project cannot be built. When mutually exclusive alternatives of this nature are met, we can choose between them by selecting the project that has the larger net present worth when discounted at a suitable opportunity cost of capital.

Tables 10-7 through 10-9 illustrate how these computations work and also why relying on a direct comparison of the internal rates of return or net benefit-investment ratios can lead to an erroneous investment decision. In table 10-7, we have a highly remunerative, small-scale irrigation scheme costing 500 thousand currency units in project year 1 that preempts the site available. At a 12 percent opportunity cost of capital, it has a net present worth of 441.2 thousand currency units. An alternative large-scale project costing 2,500 thousand currency units in project years 1 and 2 is presented in table 10-8. The large-scale project has a net present worth at a 12 percent opportunity cost of capital of 683.1 thousand currency units, and on the basis of the net present worth criterion we would select it. If we choose the smaller scheme, we would forgo a net present worth of 241.9 thousand currency units that would otherwise be available to the society (683.1 − 441.2 = 241.9). Recall that if the opportunity cost of capital is set correctly we would be able to implement *all* projects having a positive net present worth at that opportunity cost. Although this approach requires an acceptable estimate of the opportunity cost of capital, if one is available then the method tells us easily and unambiguously which mutually exclusive alternative to accept.

But if we compare the internal rates of return of the two projects, we find that the smaller project has an internal rate of return of 27 percent compared with 16 percent for the larger project. On this basis, we would choose the smaller project. A similar outcome would occur if we tried to use the net benefit-investment ratio to select between these mutually exclusive alternative projects. The smaller project has the larger net

Table 10-8. *Measures of Project Worth of Alternative Irrigation Schemes: Large-scale Alternative*
(thousands of currency units)

Project year	*Gross cost*	*Discount factor 12%*	*Present worth 12%*	*Gross benefit*	*Present worth 12%*	*Incremental net benefit (cash flow)*	*Present worth 12%*	*Discount factor 15%*	*Present worth 15%*	*Discount factor 20%*	*Present worth 20%*
1	1,500.0	0 893	1,339.5	—	—	−1,500.0	−1,339.5	0 870	−1,305.0	0.833	−1,249.5
2	1,000.0	0.797	797.0	—	—	− 1,000.0	− 797 0	0.756	− 756 0	0 694	− 694.0
3	100.0	0.712	71.2	350.0	249 2	+ 250.0	+ 178 0	0 658	+ 164.5	0.579	+ 144.8
4	100.0	0 636	63.6	450.0	286.2	+ 350.0	+ 222.6	0.572	+ 200.2	0.482	+ 168 7
5	100 0	0.567	56.7	550.0	311.8	+ 450.0	+ 255.2	0.497	+ 223 6	0.402	+ 180.9
6–20	100.0	3 864	386.4	660 0	2,550 2	+ 560 0	+2,163 8	2 907	+1,627.9	1.879	+1,052 2
Total	4,300.0	7.469	2,714 4	11,250.0	3,397.4	+6,950.0	+ 683.1	6.260	+ 155.2	4.869	− 396.9

Net present worth at 12 percent = +683.1

Economic rate of return = 15 + 5(155.2 ÷ 552.1) = 15 + 5(0 28) = 16 percent

N/K *ratio at 12 percent* = 2,819.6 − 2,136.5 = 1.32

benefit-investment ratio of 1.99, so we would select it over the larger project, which has a net benefit-investment ratio of only 1.32. But we know from the discussion of the application of the net present worth criterion that this would be an erroneous choice because we would be forgoing the additional wealth the larger project could create. When we use the internal rate of return criterion, we can avoid this error if we discount the differences between the cash flows of the two projects as is done in table 10-9. There we find that the internal rate of return to the stream of the differences is 14 percent. In other words, if we expand the project from the smaller alternative to the larger, the return to our additional investment is 14 percent. The proper choice criterion, then, is whether the return to our additional investment is above the cut-off rate. Since the cut-off rate in this example is taken to be 12 percent, the return on the additional investment would still be above the cut-off, and we would reject the smaller project in favor of the larger.

Different scales of a project

Sometimes we may wish to choose between a smaller version of a project and a larger version of the same project. Such a case arose in a Brazilian forestry project. The smaller version of the project consisted simply of cutting logs and exporting the round wood; it had a positive net present worth, quite a high economic rate of return, and an attractive net benefit-investment ratio. A somewhat larger version of the project included a sawmill; it had a larger net present worth than the smaller version, but a lower economic rate of return and a smaller net benefit-investment ratio. We could consider the larger version a mutually exclusive alternative to the smaller version.

Applying the net present worth criterion, we would correctly choose the larger version. Note, however, that simply applying directly the economic rate of return or net benefit-investment ratio criterion would have led to an erroneous investment decision.

In this case, undertaking the small project does not preempt the site. We can choose, if we wish, to undertake the small project and then proceed to expand it. Under these circumstances, we do our analysis not of the small version versus the large version, as if the two were mutually exclusive projects, but of the small version as the first phase of a two-phase program. By the net present worth criterion, we know from our earlier discussion that the smaller version, now called phase I, has a positive net present worth, so we would accept it. Then, if we tested the expansion necessary to reach the larger version, now called phase II, we would find that this phase also has a positive net present worth, and so we would accept it, too. If we wanted to use the internal rate of return approach, the economic rate of return of the second phase of the program would be the economic rate of return of the differences between the incremental net benefit streams of the two versions. Similarly, the net benefit-investment ratio of the phase-II project would be the net benefit-investment ratio of the differences of the incremental net benefit streams

Table 10-9. *Measures of Project Worth of Alternative Irrigation Schemes: Differences between Alternatives*
(thousands of currency units)

Project year	*Cash flow of large-scale scheme*	*Cash flow of small-scale scheme*	*Differences between cash flows*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 15%*	*Present worth 15%*
1	−1,500 0	− 500 0	−1,000.0	0 893	− 893.0	0.870	− 870.0
2	−1,000 0	+ 135 0	−1,135 0	0.797	− 904.6	0.756	− 858.1
3	+ 250 0	+ 135 0	+ 115 0	0.712	+ 81.9	0.658	+ 75.7
4	+ 350 0	+ 135.0	+ 215.0	0.636	+ 136.7	0.572	+ 123.0
5	+ 450 0	+ 135 0	+ 315.0	0 567	+ 178.6	0 497	+ 156.6
6–20	+ 560 0	+ 135 0	+ 425.0	3.864	+1,642 2	2.907	+1,235 5
Total	+6,950 0	+2,065.0	+4,885 0	7.469	+ 241.8	6.260	− 137.3

Net present worth at 12 percent of the differences between incremental net benefit streams = +241 8

Economic rate of return of the differences between incremental net benefit streams

= 12 + 3(241 8 − 379.1) = 12 + 3(0 64) = 14 percent

of the two versions. Breaking a project down into phases is the more direct approach and the more easily understood. Such an approach permits us to apply any of our measures of project worth directly without further manipulation.

Of course, if we have sufficient administrative and other resources, we may very well implement two phases—or even more—of a project simultaneously. By analyzing each phase separately, we can tell directly from our analysis how large the project can be before we reach a phase that has a negative net present worth, an economic rate of return below our cut-off rate, or a net benefit-investment ratio less than that of alternative project opportunities.

Different timing of a project

A special case of the choice among mutually exclusive projects is the question of whether to begin a project immediately or to postpone it. The same project begun today or at some future time may be considered, from an analytical standpoint, to be two different, mutually exclusive projects.

Postponing a project can be advantageous *only* if the potential benefit or cost stream will increase independently of when a project is begun. In most agricultural production projects, this is not the case. Rather, it is assumed that costs and benefits will come at some given period of time after the start of the project. If the project is postponed, both costs and benefits will also be postponed and for the same period of time.

Questions of the best time to begin implementation can arise in agricultural projects when there is a processing facility to be constructed. We may want to establish sugar beets in a new area. We have an idea of the maximum rate at which we can expand the area for sugar beets given the limitations imposed by extension work, rates at which farmers will adopt new practices, and the like. We have a choice between shipping the beets to another area for processing—incurring both a transport cost and a loss of sucrose because of natural deterioration in the raw material—or building a new factory of a minimum economic size. Here we have a case where timing should be assessed. The potential benefit of the project grows independently of the beet factory up to its capacity because the benefit is dependent upon the rate at which farmers increase their output of beets. In the first years of the project it might be too expensive to provide for local processing, but at some point the savings in transport cost and sucrose loss will make it economic to build the factory. The problem is when is it most economic to begin.

There are two general approaches commonly employed to determine the optimal time to begin a project. The simplest timing test to calculate, and probably the most widely used in practice, is the "first-year return" method. This technique makes an implicit assumption that once benefits begin they will be rising or constant, but this is the most common situation in all kinds of projects and so is not a serious drawback. In this test, the net benefit stream in the first year the stream is positive is

divided by the total of the net benefit stream in those years it is negative. The result expressed in percentage terms is the first-year return. The optimal time to begin the project is the earliest year for which the net benefit stream for a project begun in that year has a first-year return exceeding the opportunity cost of capital. If the project begins earlier, for at least the first year it will fail to earn the opportunity cost of capital, and so it would be better to postpone implementation and use the money elsewhere. If the project begins later, a chance to earn the opportunity cost of capital on the initial investment will be passed by.

The second timing test, somewhat more difficult to calculate than the first-year return test but the easiest test to interpret, is to compute the net present worth of the project by assuming it will begin in different years and by discounting at the opportunity cost of capital. (The same year is taken as t_0 for all of the alternative net present worth computations.) The project should begin in that year when the net present worth is the greatest. Before that time, postponing the project will increase its net present worth at the given opportunity cost of capital; after that time, the net present worth of the project will be less than it need be.

A very common instance of the need to determine optimal timing occurs in relation to traffic growth in road projects. The application of the methods of determining the optimal time to begin a project can be illustrated by the Kenya feeder road example laid out in table 10-10. The cost of constructing the road, divided equally between two years, is estimated at K£760.0 thousand. (The symbol for Kenyan pounds is K£. Since this analysis was made, the unit of currency used in budgeting in Kenya has been changed from pounds to shillings, or KSh.) The road is assumed to have an economic life of thirty years. The earliest the project could have begun was 1970. Once the road was complete, there would be a two-year period while the traffic built up rapidly as people learned about the new road and new traffic was generated. After that, the traffic level would be determined by the general economic conditions of the area and was assumed to grow by 9 percent a year until 1991 and to be constant thereafter for the balance of the economic life of the road. The incremental net benefit streams given in table 10-10 are based on the benefit stream derived from the traffic estimates. (The traffic estimates were made on the basis of growth over 20 years on the assumption that the road was begun in 1970. It will be seen that, even if traffic were assumed to continue to grow after 1991, the optimal time to begin the project would not change.) A residual value was assumed that was based on linear depreciation in those cases where the benefit stream does not last a full thirty years. An opportunity cost of capital of 12 percent is assumed.

To illustrate the first-year return method, we may consider the effect of beginning the road in 1973. The first year the net benefit stream is positive, it amounts to K£79.7 thousand. This is only 10 percent of the investment cost (taken to be the sum of the negative values of the net present worth stream), an indication that it is too soon to begin the project [$79.7 \div (380.0 + 380.0) \times 100 = 10$]. If we test for beginning the

road in 1974, the net benefit stream in the first year the net present worth is positive amounts to K£86.4, which is only 11 percent of the investment, and it is still too early to begin [86.4 ÷ (380.0 + 380.0) × 100 = 11]. But now if we test for beginning the road in 1975, when the net benefit stream the first year it is positive amounts to K£94.5 thousand, we find the first year return to be 12 percent [94.5 ÷ (380.0 + 380.0) × 100 = 12]. Since 12 percent is our opportunity cost of capital, the first-year return method indicates that 1975 is the optimal year to begin the project.

To determine the optimal time to begin the project using the net present worth method, the net present worth of the road was computed for each timing alternative from 1970 through 1977. The calculation took 1969 as t_0 (that is, 1970 = t_1). The net present worth reaches its greatest value of K£300.6 if the road were to be postponed five years and construction begun in 1975. This, then, is the optimal timing alternative, a result consistent with that we obtained using the first-year return method. Beginning the road either before or after 1975 would result in a lower net present worth.

In this example of mutually exclusive timing alternatives, an investment decision based only on a simple economic rate of return computation would have led to an erroneous choice. Beginning the project in 1970 would yield an overall economic rate of return from the project as a whole of 15 percent. Since this is well above the opportunity cost of capital, at first glance it might seem justifiable to proceed with the project. But we know from our first-year return analysis that if the project is begun in 1970 the return to the capital invested in the first year a positive benefit is received is only 8 percent, and it would thus be better to postpone the investment. Choosing the optimal starting year of 1975 means that the project will have an economic rate of return of 19 percent. If we postpone the project still further, we know that the present worth of the project at the opportunity cost of capital falls—but note that the simple economic rate of return to the project as a whole continues to rise, and this might be misleading to the unwary or ill-advised project analyst.

The internal rate of return criterion can be manipulated to indicate the optimal timing by discounting the differences between the cash flows in each succeeding year until the internal rate of return to the incremental cash flow just equals the opportunity cost of capital. This calculation, however, is complex and more difficult to interpret than either the first-year return or the net present worth approach.

In the Kenya example, the net benefit-investment ratio also indicates the optimal timing directly, but since the net benefit-investment ratio cannot in general be relied on to choose between mutually exclusive projects, its use to determine optimal timing is inadvisable.

Choice between technologies (crossover discount rate)

When there are technological alternatives by which we can realize the same result when designing a project, we have an instance of mutually

Table 10-10. *Determination of Optimal Timing, Third Highway Loan Project, Feeder Road Number 10, Kenya*
(thousands of K£)

Year	*Incremental net benefit assuming construction to begin in:*							
	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*
1970	−380.0	—	—	—	—	—	—	—
1971	−380.0	−380.0	—	—	—	—	—	—
1972	+ 61.0	−380.0	−380.0	—	—	—	—	—
1973	+ 69 1	+ 67.0	−380.0	−380.0	—	—	—	—
1974	+ 77.7	+ 75.3	+ 73.0	−380.0	−380.0	—	—	—
1975	+ 84.7	+ 84 7	+ 82 7	+ 79.7	−380.0	−380.0	—	—
1976	+ 92 3	+ 92.3	+ 92.3	+ 89.7	+ 86.4	−380.0	−380.0	—
1977	+100.6	+100.6	+100.6	+100.6	+ 97.8	+ 94.5	−380.0	−380.0
1978	+109.7	+109.7	+109.7	+109.7	+109.7	+106 9	+102.6	−380.0
1979	+119.6	+119.6	+119.6	+119.6	+119.6	+119.6	+116.0	+111.8
1980	+130.3	+130.3	+130.3	+130.3	+130.3	+130.3	+130.3	+126.4
1981	+142 0	+142.0	+142.0	+142.0	+142.0	+142.0	+142.0	+142.0
1982	+154.8	+154 8	+154.8	+154.8	+154.8	+154.8	+154.8	+154.8
1983	+168.8	+168.8	+168.8	+168.8	+168.8	+168 8	+168.8	+168.8
1984	+183.9	+183.9	+183.9	+183.9	+183.9	+183.9	+183.9	+183.9
1985	+200.5	+200 5	+200.5	+200.5	+200.5	+200.5	+200.5	+200.5
1986	+218.5	+218.5	+218.5	+218.5	+218.5	+218 5	+218.5	+218.5
1987	+238.2	+238.2	+238.2	+238.2	+238.2	+238.2	+238.2	+238.2

1988	+259.7	+259.7	+259.7	+259.7	+259.7	+259.7	+259.7	+259.7
1989	+283.0	+283.0	+283.0	+283.0	+283.0	+283.0	+283.0	+283.0
1990	+308.5	+308.5	+308.5	+308.5	+308.5	+308.5	+308.5	+308.5
1991–2000	+336.3	+336.3	+336.3	+336.3	+336.3	+336.3	+336.3	+336.3
2001	+336.3	+361.6[a]	+386.9[b]	+412.2[c]	+437.5[d]	+462.8[e]	+488.1[f]	+513.4[g]
Present worth at 12 percent	+238.9	+262.2	+279.1	+290.8	+297.6	+300.6	+299.6	+295.4
First-year return (percent)	8	9	10	10	11	12	14	15
Economic rate of return (percent)	15	16	16	17	18	19	20	21
N/K ratio	1.31	1.35	1.37	1.38	1.39	1.40	1.39	1.39

Source: Adapted from World Bank, "Appraisal of a Third Highway Project, Kenya," PTR-24a (Washington, D.C., 1969). Since this analysis was made, the unit of currency used in budgeting in Kenya has been changed from pounds to shillings (KSh).

a. Includes residual value of K£25.3 thousand.
b. Includes residual value of K£50.6 thousand.
c. Includes residual value of K£75.9 thousand.
d Includes residual value of K£101.2 thousand.
e. Includes residual value of K£126.5 thousand.
f. Includes residual value of K£151.8 thousand
g. Includes residual value of K£177.1 thousand.

exclusive alternatives because the choice of one technology precludes the use of another for the same purpose. The alternative we choose will be the one with the lower net present worth, but, if the total undiscounted cost of using the different alternatives is different and they have differing time profiles, the alternative we choose may depend on the opportunity cost of capital.

Suppose we have a choice between two grain storage systems—one that uses silos and bulk handling and that has the lower undiscounted cost, and the other that uses warehouses and bags. The bulk handling system involves a high initial investment for silos but has low upkeep. The alternative system based on warehouses and bagging has a much lower construction cost but will entail substantial annual operating cost. At a low discount rate, the silo system with its high initial cost but low operating cost will have the lower net present worth—thus it would be preferred. At a high discount rate, however, the warehouse and bagging system with its low initial cost but high operating cost will have the lower net present worth. At some discount rate, both alternatives will have the same net present worth, and we will be indifferent on economic grounds which alternative we choose. This is known as the "crossover (or equalizing) discount rate," and it can be found either graphically or by discounting the differences between the cost streams. If the cost of capital or cut-off rate is below the crossover discount rate, we will prefer the alternative that entails the higher initial capital outlay but lower expenditure in the future. Above the crossover discount rate, we will prefer the technological alternative with the lower initial cost, even though this involves higher operating cost later.

We may illustrate this with a forestry project in Tunisia; the analysis is laid out in tables 10-11 through 10-13 and in figure 10-1. It was proposed to clear an area covered with maquis, a scrubby underbrush found in the Mediterranean region, at the rate of 400 hectares a year for five years to prepare the ground for reforestation. Two technological alternatives

Table 10-11. *Choice between Manual and Mechanical Land Clearing in Tunisia: Manual Clearing Alternative*
(US$)

Project year	*Wages*[a]	*Other cost*[a]	*Total cost*	*Present worth 10%*	*Present worth 15%*
1	44,050	3,800	47,850		
2	44,050	3,800	47,850		
3	44,050	3,800	47,850	181,399	160,393
4	44,050	3,800	47,850		
5	44,050	3,800	47,850		
Total	220,250	19,000	239,250	181,399	160,393

US$ U.S. dollars.

Source: Personal communication from Mr. Hans Warvinge, Swedish International Development Authority (December 1971).

a. All values at market prices.

Table 10-12. *Choice between Manual and Mechanical Land Clearing in Tunisia: Mechanical Clearing Alternative*
(US$)

Project year	*Equipment cost*[a]	*Operation and maintenance*[a]	*Total cost*	*Present worth 10%*	*Present worth 15%*
1	90,700[b]	21,586	112,286	102,068	97,689
2	0	25,134	25,134	20,761	19,001
3	0	25,134	25,134	18,876	16,538
4	0	26,227	26,227	17,913	15,002
5	0	26,227	26,227	16,287	13,035
Total	90,700	124,308	215,008	175,905	161,265

Source: Same as table 10-11.
a. All values at market prices
b. Tractor and clearer c.i.f. Tunis, taxes included.

were available. The land could be cleared manually at a cost of US$47,850 per year spread evenly over the five-year period for an undiscounted total cost of US$239,250 (table 10-11). Alternatively, tractors and clearing equipment could be purchased and the area cleared mechanically at a lower undiscounted total cost of US$215,008 (table 10-12). The mechanical clearing alternative involved a large initial capital expenditure of US$90,700; after that, however, operation and maintenance costs would only be some US$25,000 a year.

The proper choice between these two alternatives must allow for the time value of money. If a discount rate of 10 percent is assumed, we find the mechanical alternative continues to be cheaper and has the lower present worth. At 15 percent, however, we find the manual method has the lower present worth and, hence, costs less. If we subtract year by year the cost stream of the cheaper undiscounted alternative (in this case, the mechanical clearing) from the more expensive undiscounted alternative (the manual clearing) and then find the discount rate that brings the stream of the differences between the cost streams to zero, we will find that discount rate at which the present worths of the two alternatives are equal (hence, the term "equalizing discount rate"). From an economic standpoint, at this rate we are indifferent about the alternatives. As shown in table 10-13 for the Tunisian example, this crossover or equalizing discount rate is 14 percent. (This discount rate may also be derived graphically as illustrated in figure 10-1.) If our opportunity cost of capital were 10 percent, we would prefer the mechanical clearing alternative, assuming that our criteria were based strictly on cost grounds. If the opportunity cost of capital were 15 percent, we would prefer the manual clearing alternative, even though this is the more expensive alternative in absolute (undiscounted) terms. If the opportunity cost of capital were 14 percent, on economic grounds we would be indifferent about the alternatives.

In Tunisia, where the opportunity cost of capital was probably not much, if any, less than 14 percent, the manual alternative would doubt-

Table 10-13. *Choice between Manual and Mechanical Land-clearing Alternatives in Tunisia: Crossover Discount Rate*
(US$)

Project year	*Differences between cost streams*	*Present worth 10%*	*Present worth 15%*
1	−64,436	−58,572	−56,059
2	+22,716	+18,763	+17,173
3	+22,716	+17,060	+14,947
4	+21,623	+14,769	+12,368
5	+21,623	+13,428	+10,747
Total	+24,242	+ 5,448	− 824

Crossover discount rate = 10 + 5[5,448 − (5,448 + 824)] = 10 + 5(0.87) = 14 percent

Source: Same as table 10-11.

lessly be chosen if for no other reason than the employment effect manual clearing would have. Note, too, that the example uses market prices. If we were to shadow-price labor at 50 percent of its wage, the undiscounted cost of the manual clearing alternative falls to US$129,125 [(220,250 × 0.50) + 19,000 = 129,125], which makes it well below the undiscounted cost of the mechanical alternative even if we reduce the cost of the tractor and clearing equipment by the amount of duties and taxes. At the shadow wage, there would be no case at all for the mechanical alternative in this example. In other projects, however, the effect of the shadow wage would be to reduce the crossover discount rate—possibly to move it below a cut-off rate so that a labor-intensive alternative that would not be attractive at market prices might prove to be the preferable alternative if shadow prices were used in the economic analysis.

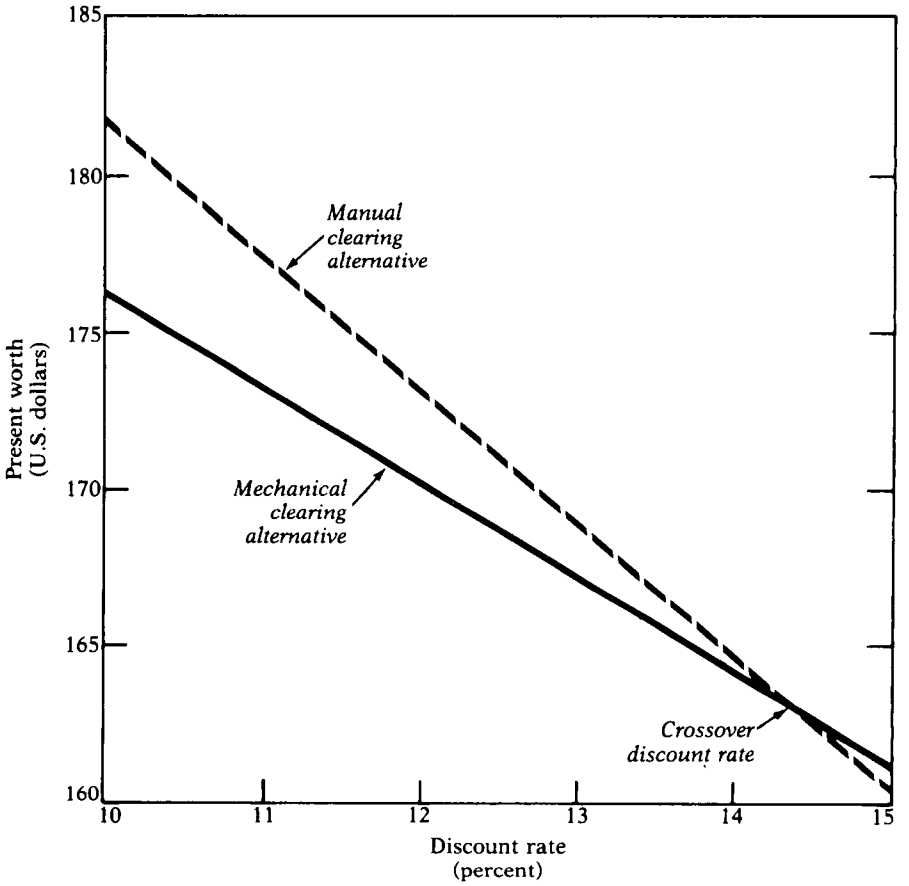
This Tunisian example shows vividly how low (perhaps subsidized) interest rates and high wages (perhaps the result of minimum wage regulations) can encourage mechanization and reduce employment.

Additional purposes in multipurpose projects

A variation of the problem of mutually exclusive alternatives arises in multipurpose projects. In these, a project design that includes one group of purposes is a mutually exclusive alternative to another project design that includes a different group of purposes. The problem is frequently met in rural development projects, and another common example is found in river basin development projects.

The reason we are interested in multipurpose projects, of course, is that often it is possible to provide a group of related goods and services more cheaply from a single project than it is to provide the same benefits from the most economic, alternative single-purpose projects. But there is a danger that a very beneficial purpose (flood control, perhaps) may drive up the overall economic rate of return and thus hide another purpose (irrigation, perhaps) that should be omitted.

Figure 10-1. *Graphic Derivation of Crossover Discount Rate, Choice between Mechanical and Manual Land-clearing Alternatives in Tunisia*



Source: Table 10-5.

Projects may conveniently be tested for the desirability of an additional purpose by determining the net present worth of the alternative groups of purposes at the opportunity cost of capital. If the project has a greater net present worth with an additional purpose than without it, then the additional purpose is justified. But if the net present worth is reduced by including an additional purpose, then obviously it would be undesirable to include the additional purpose in the project.

The method of analysis is illustrated in tables 10-14 through 10-16. A multipurpose river basin project can be built to provide only flood control and power benefits, or it can be expanded to include an irrigation component. The separable cost wholly attributable to each purpose is given in the first part of table 10-14. These indicate the extent to which the cost of the project would be reduced were one component omitted. In this instance, omitting irrigation reduces the cost of the project by US$18,965 thousand. The alternative cost of providing each benefit in the project by means of the most economic alternative single-purpose proj-

Table 10-14. *Separable and Alternative Costs, Multipurpose River Basin Project, United States*
(thousands of US$)

Project year	*Flood control*	*Irrigation*	*Power*
	Separable cost		
1	84	1,132	600
2	1,244	1,970	1,530
3	907	2,865	2,085
4–100	5	134	61
Total	2,720	18,965	10,132
	Alternative cost		
1	2,380	1,880	715
2	4,740	5,270	2,100
3	1,370	2,565	1,495
4–100	22	220	226
Total	10,624	31,055	26,232

Source: Adapted from U S. Government, Department of the Interior, Bureau of Reclamation, *Reclamation Instruction Series 110, Project Planning* (Washington, D.C., 1959), p. 116.5.19.

ect is given in the second part of table 10-14. If the present worth of providing the same purpose by a single-purpose alternative were less than the present worth of the separable cost for providing that same purpose in the multipurpose project, there would be no grounds for including that purpose in the multipurpose project. In table 10-15, discounting at 2.5 percent (the rate in use at the time this analysis was done) shows that the net present worth of the project increases from US$8,273 thousand to US$10,935 thousand when the irrigation component is added. The investment decision, then, would be to include the irrigation component in the project. Had the net present worth with irrigation been less than US$8,273 thousand, the investment decision would have been to omit the irrigation component.

The same investment decision would have been reached if the method of discounting the differences between the cash flows had been used, although this involves more calculation and more chance of error. This approach is illustrated in table 10-16. There the economic rate of return to the irrigation component is found to be 4 percent. Since this is greater than the opportunity cost of capital or cut-off rate of 2.5 percent, the investment decision would be to accept the irrigation component. Note, however, that if one were simply to calculate an internal rate of return for the two versions of the project, with irrigation and without irrigation, the version without irrigation has a slightly higher internal rate of return. If one were not careful about the method of analysis using the internal rate of return for mutually exclusive projects, the wrong investment decision might be made. (Note the relation between the net present worth analysis in table 10-15 and the analysis discounting the differences between cash flows in table 10-16. The differences of the net present worths of the cash flows discounted at 2.5 percent in table 10-15 is US$2,662 thousand

Table 10-15. *Measures of Project Worth without and with Irrigation, U.S. Multipurpose River Basin Project*
(thousands of US$)

Project year	Cost	Benefit: Flood control	Benefit: Irrigation	Benefit: Power	Incremental net benefit (cash flow)	Discount factor 2.5%	Present worth 2.5%
			Without irrigation				
1	2,456	—	—	—	− 2,456	0.976	− 2,397
2	6,218	—	—	—	− 6,218	0.952	− 5,920
3	1,983	—	—	—	− 1,983	0.929	− 1,842
4–100	72	271	—	347[a]	546	33 758	+18,432
Total	17,641	26,287	—	33,659	+42,305	36.615	+ 8,273
Net present worth at 2.5 percent without irrigation = US$+8,273							
Internal rate of return without irrigation = 4.8 percent[b]							
N/K *ratio at 2.5 percent without irrigation* = US$18,432 − US$10,159 = 1.81[b]							
			With irrigation				
1	3,588	—	—	—	− 3,588	0.976	− 3,502
2	8,188	—	—	—	− 8,188	0.952	− 7,795
3	4,848	—	—	—	− 4,848	0.929	− 4,504
4–100	206	271	380	347[a]	+ 792	33.758	+26,736
Total	36,606	26,287	36,860	33,659	60,200	36.615	+10,935
Net present worth at 2.5 percent with irrigation = US$+10,935							
Internal rate of return with irrigation = 4.5 percent[b]							
N/K *ratio at 2.5 percent with irrigation* = US$26,736 ÷ US$15,801 = 1.69[b]							

Source: Same as table 10-14.
a. See the text for a discussion about valuing the power benefit.
b. See the text for a discussion about interpreting these measures.

(10,935 − 8,273 = 2,662), which is exactly the net present worth of the differences of the streams of cash flows discounted at 2.5 percent as shown in table 10-16.)

For illustrative purposes, the net benefit-investment ratio has been included in table 10-15. Note that the net benefit-investment ratio without irrigation, 1.81, is larger than the net benefit-investment ratio with irrigation, 1.69. Once again we find that the net benefit-investment ratio cannot be relied on to choose between mutually exclusive alternatives.

A complication arises in regard to the benefit of the power component. The economic benefit of electricity is generally considered not possible to estimate. What *is* the benefit of electricity, especially if much of it goes for household use? In economic analysis of single-purpose projects, this difficulty is usually resolved by assuming that alternative projects generating the same amount of electricity will have an equivalent benefit and by simply choosing the one for which the present worth of the cost is lowest. In analyzing projects such as this multipurpose one, however, a different approach to valuing power is conveniently adopted. It may be assumed that if power consumers are willing to pay the price that would have to be charged to provide the same amount of electricity by the most economic single purpose as indicated in the second part of table 10-14, then the economic value of the power component in the multipurpose

Table 10-16. *Discounting Differences between Cash Flows, With and Without Irrigation, U.S. Multipurpose River Basin Project*
(thousands of US$)

Project year	*Incremental net benefit (cash flow) with irrigation*	*Incremental net benefit (cash flow) without irrigation*	*Differences between cash flows*	*Discount factor 2.5%*	*Present worth 2.5%*	*Discount factor 5%*	*Present worth 5%*
1	− 3,588	− 2,456	− 1,132	0.976	−1,105	0.952	−1,078
2	− 8,188	− 6,218	− 1,970	0.952	−1,875	0.907	−1,787
3	− 4,848	− 1,983	− 2,865	0.929	−2,662	0.864	−2,475
4–100	+ 792	+ 546	+ 246[a]	33.758	+8,304	17.125	+4,213
Total	+60,200	+42,305	+17,895	36 615	+2,662	19.848	−1,127
Internal rate of return of irrigation component = 2.5 + 2.5(2,662 − 3,789) = 4 percent[b]							

Source: Same as table 10-14.
a. See the text for a discussion about valuing the power benefit
b. See the text for a discussion about interpreting this measure.

project is at least that much. That being the case, we may take the annual benefit of the power to be at least the annual equivalent of the net present worth of the cost of providing the power by means of the most economic single-purpose alternative.

In this instance, if we discount the stream of costs for the most economic single-purpose power alternative as given in the second part of table 10-14 at the opportunity cost of capital of 2.5 percent, we reach a net present worth of US$11,715 thousand. To convert this net present worth to an annual equivalent, we need the capital recovery factor for the period from the 4th through the 100th year of the project, since power from the single-purpose alternative is assumed to begin to flow in the 4th year. This cannot be determined conveniently from a commonly used set of compounding and discounting tables such as those in Gittinger (1973). We can, however, calculate the capital recovery factor directly by determining the present worth of an annuity factor for the 4th through the 100th years and by then taking the reciprocal of that, since the capital recovery factor is the reciprocal of the present worth of an annuity factor. (This method is discussed in more detail in the section on "Joint Cost Allocation" in chapter 6.) The present worth of an annuity factor at 2.5 percent for 100 years is 36.614 105. This may be obtained from a detailed set of compounding tables, from calculation along the lines of the discussion in the last section of this chapter, or from the formula in appendix B. The present worth of an annuity factor for 2.5 percent for 3 years is 2.856 024, so that the present worth of an annuity factor at 2.5 percent for the 4th through the 100th years is 33.758 081 (36.614 105 − 2.856 024 = 33.758 081). The capital recovery factor for the 4th through the 100th years at 2.5 percent can then be obtained by taking the reciprocal of the present worth of an annuity factor, or 0.029 623 (1 ÷ 33.758 081 = 0.029 623). We then apply that factor to the net present worth at 2.5 percent of the stream of costs of providing the power by the most economic single-purpose alternative, US$11,715. The result is the annual value of the cost of providing the power by the single-purpose alternative, US$347 thousand (11,715 × 0.029 623 = 347). This value can then be used to estimate the present worth of the multipurpose project with and without the irrigation component. A fuller discussion of valuing electricity will be found in van der Tak (1969).

Applying Contingency Allowances

For many estimates of project costs, especially costs of those projects in which there is a considerable element of construction in the earlier years, the engineers will often include a contingency allowance. We noted in chapter 2 that physical contingency allowances and contingency allowances intended to reflect relative price changes are real costs in both financial and economic analysis and should be incorporated directly into the project accounts even when the analyst is working in constant prices.

The contingency allowance intended to allow for general inflation,

however, does not enter into the project accounts, either financial or economic, when the analyst is working in constant prices. This means that when inflation is expected to be significant, a separate financing plan will be needed to give those responsible for making budget allocations a better idea of the amounts in current terms that they will be asked to make available.

Because future price increases can affect costs only until work is completed, the overall contingency allowance for inflation is built up by applying the appropriate compounding factors to the amount to be expended each year. Suppose we take a project with an expected total cost of US$390 thousand in constant terms as of the beginning of the project, or t_0. Construction costs are to be incurred equally each year over a three-year construction period. We expect inflation to be 8 percent a year during construction. We can lay out the computation as follows (costs are in thousands of U.S. dollars):

Year	*Project cost in constant terms*		*Compounding factor for 1 at 8 percent*		*Project cost in current terms*
1	130	×	1 080	=	140
2	130	×	1.166	=	152
3	130	×	1.260	=	164
Total	390				456

The total cost for the project in current terms would thus be US$456 thousand, and the price contingency would be 17 percent [(456 − 390) ÷ 390 × 100 = 17]. This, of course, is quite different from the 26 percent price contingency we would obtain if we were to compound the whole project cost in constant terms over the three-year period [390 × 1.260 = 491; (491 − 390) ÷ 390 × 100 = 26].

Contingency allowances are usually not included for the operating costs of a project once the initial investment stage is passed. Rather, problems such as higher than anticipated production expenditures are customarily analyzed by using sensitivity analysis, and a judgment is then made about whether to change the design of the project or to abandon it.

In agricultural credit projects, it is generally not necessary to include contingency allowances. Changes in unit costs for this kind of project will primarily affect the number of loans that can be made with the funds available rather than the economic justification of the project itself. Contingencies in agricultural credit projects usually will, however, be treated in the discussion of the economic justification of the project, perhaps in conjunction with the sensitivity analysis.

Contingency allowances are best shown separately in project tables, with appropriate explanations of how they were calculated included in the accompanying text and notes. To avoid double counting, any contingency allowances already included in the basic material used to prepare the project analysis should be eliminated. The amount of contingency provision will vary with the nature of the project and the general components of the project. Contingency allowances should be determined item

by item for each project, not based on some national standard allowance. In general, contingency allowances should not be large enough to cover almost any cost overrun, since the possibility of so large a change occurring is small. Such excessive prudence will reduce the pressure for careful cost estimation, relax pressure for tight cost control during project execution, and result in misleading underestimates of the net present worth, the financial and economic return, or the net benefit-investment ratio.

Physical contingency allowances usually are estimated separately for each major category of cost and separately for local and foreign exchange costs. Projects that include large civil engineering works require higher contingency allowances than projects that cover only the supply and erection of equipment. The cost of engineering works will be influenced by such factors as the topography and geology of the project area, the amount of field work necessary to prepare the detailed designs, unforeseen technical difficulties (especially if the project involves subsurface work), the risk of underestimating the amount of work actually required, changes in design during construction, and unusually bad weather that may interrupt work. If large amounts of equipment are involved, contingencies may be appropriate to allow for errors in estimating the exact amount of equipment and the quantity of spare parts needed.

Contingency allowances for relative price changes during the early investment phase of a project may reflect anticipated influences arising from domestic price increases, the expected trend of prices in leading supplier countries, price trends for particular kinds of work or kinds of equipment to be used, and the possible effect of the project in exerting a strong upward pull on prices of locally supplied labor and raw materials. [A projected index of international inflation is included in *Price Prospects for Major Primary Commodities* (World Bank 1982*a*), which may be helpful in estimating price trends in supplier countries and for imported equipment.]

Replacement costs

Many agricultural projects require investments that have different lifetimes. A good example is found in the case of a pump irrigation scheme in which the earthworks and pump platforms may be expected to last twenty-five to fifty years but the pumps themselves may have a life of only seven to fifteen years. In preparing the analysis, allowance must be made for the replacement cost of the pumps during the life of the project.

Treatment of replacement costs is simple. The analyst includes them among the capital items for the appropriate year in the project analysis. In analysis of the net present worth, internal rate of return, and net benefit-investment ratio, the replacement costs are then netted out when the cash flow is computed. This may make the cash flow for that particular year negative, but only rarely in an agricultural project could this introduce analytical complications (see the subsection on "More than one possible internal rate of return" in chapter 9).

Table 10-17. *Treatment of Replacement Cost, Lift Irrigation Project, India*
(thousand of Rs)

Project year	*Investment cost*	*Incremental benefit*[a]	*Incremental net benefit (cash flow)*	*Discount factor 12%*	*Present worth 12%*	*Discount factor 30%*	*Present worth 30%*	*Discount factor 35%*	*Present worth 35%*
1	469	0	− 469	0 893	− 419	0.769	−361	0.741	−348
2	223	0	− 223	0.797	− 178	0.592	−132	0.549	−122
3	0	155	+ 155	0.712	+ 110	0.455	+ 71	0 406	+ 63
4–8	0	310	+ 310	2.566	+ 795	1.109	+344	0.902	+280
9	223[b]	310	+ 87	0 361	+ 31	0.094	+ 8	0.067	+ 6
10–15	0	310	+ 310	1.483	+ 460	0.249	+ 77	0.160	+ 50
16	223[b]	310	+ 87	0.163	+ 14	0.015	+ 1	0.008	+ 1
17–22	0	310	+ 310	0.671	+ 208	0.040	+ 12	0 019	+ 6
23	223[b]	310	+ 87	0.074	+ 6	0.002	0	0.001	0
24	0	310	+ 310	0.066	+ 20	0.002	+ 1	0.001	0
25	0	469[c]	+ 469	0.059	+ 28	0.001	0	0.001	0
Total	1,361	7,134	+5,773	7.845	+1,075	3.328	+ 21	2.855	− 64

Net present worth at 12 percent = Rs+1,075
Financial rate of return = 30 + 5[21 − (21 + 64)] = 30 + 5(0.25) = 31 percent
N/K *ratio* = Rs1,672 − Rs597 = 2.80

Rs Indian rupees.

Source: Adapted from "Report on Lift Irrigation Project in Sangli District, Maharashtra," section 18 of *Selected Agricultural Project Reports* (Pune, Maharashtra: College of Agricultural Banking, 1978), pp. 373–92.

a. The incremental benefit is aggregated from farm budgets. Operation and maintenance of the scheme are recovered by charges to farmers and are deducted from gross output as a production cost.

b. Pump replacement.

c. Includes residual value for pumps of Rs159 thousand; civil works are assumed to have no residual value.

The treatment of replacement costs is illustrated in table 10-17. The project is a lift irrigation scheme proposed for Sangli District in the state of Maharashtra in western India. The scheme would draw water from the Krishna River to serve three villages and would enable the farmers to grow hybrid sorghum, wheat, and sugarcane in addition to their traditional, rainfed crops. The project would take two years to complete. Once in operation, the civil works associated with the pumps could be expected to last at least twenty-five years. The pumps themselves, however, are expected to be replaced every seven years. In table 10-17, the investment column shows Rs223 thousand for pump replacement in years 9, 16, and 23. The project thus allows for pump replacement quite directly by simply including replacement as an investment cost in the years it is expected to occur. (Note that there is a "residual" value to allow for the unexpired life of the last pump cycle in year 25; we will return to this in the next subsection.) In this Indian example (as is generally the case), the investment cost for pump replacement is not large enough to turn the cash flow negative in any year when new pumps are to be installed, so there is no possibility that there will be more than one solution when the internal rate of return is calculated.

Residual value

Often at the end of a project there may reasonably be expected to be some residual (or terminal) value. That is, the capital asset will not have been all used up in the course of the project period, and there will be a "residual asset." The way to handle this is to treat the residual value of any capital item (say a dam or a stand of trees) as a project "benefit" during the last year of the analysis period.

An example of a residual value is found in the analysis of the Indian pump project outlined in table 10-17 and discussed in the previous subsection on replacement costs. The pumps in this project are replaced every seven years. The last pump replacement before the end of the project in year 25 occurs at the end of year 23. The pump, therefore, is expected to have been used for only two years of its seven-year life by the end of the project. The value of the remaining useful life of the pump should not properly be charged as an investment cost to the project; instead, the project should be credited with the residual value in the final year of the project. Thus, in this example the analyst added an amount equal to five-sevenths of the Rs223 thousand investment cost included in year 23 to the incremental benefit in year 25, or Rs159 thousand [$(7 - 2) \div 7 \times 223 = 159$].

On the whole, residual values will not change the net present worth, rate of return, or net benefit-investment ratio significantly unless the period of the analysis is short or the value of the capital items is quite large in relation to the value of the benefit stream. Such might be the case, for instance, in a livestock project in which a very large residual value may build up in the form of a valuable herd. For agricultural projects carried out to 25 years or so, however, the residual value will

usually not change the net present worth or the net benefit-investment ratio by more than a very small proportion, or the rate of return by as much as a percentage point. The reasons are the same ones noted in the discussion of the length of the project period. At the earning capacities of the kinds of projects we are considering, the present worth of future benefits (hence, the present worth of residual values) is just not very great. A practical result of this is that projects are quite insensitive to errors in estimating residual values. A rather gross estimate in a twenty-five-year project is adequate. Note that in table 10-17 virtually no error in estimating the salvage value could significantly affect the measures of project worth. Including residual values in the project analysis will forestall criticisms of the project analysis, or attempts to discredit a project with a low initial investment in favor of another with a high initial investment on the grounds that the analyst ignored the residual value. This may be important when discussing irrigation projects or livestock projects because the technicians' concern and attention may be largely focused on the problems associated with the capital investment in the dam or in the buildup of the breeding herd.

Domestic resource cost

In countries where there are balance of payments problems and where import substitution or export promotion is an important objective, it is useful to estimate the cost in the domestic currency required to earn a unit of foreign exchange through a proposed project. The usefulness of doing so might arise, for instance, in preparing an oil palm project in which export or avoidance of vegetable oil imports is the objective or in evaluating a fertilizer plant intended to reduce or avoid future increases in imports. It is not enough just to earn or save foreign exchange. Some idea must be formed of the cost of saving foreign exchange, and a judgment must be made about whether that cost is too high. By expressing the cost of earning or saving a unit of foreign exchange as domestic resource cost, a direct comparison may be made with the official exchange rate and various shadow prices for foreign exchange. Such a comparison is one basis for evaluating a project.

There are many approaches to estimating the domestic resource cost and numerous theoretical problems to be resolved. These have been discussed at length by Bruno (1967), whose name is so closely identified with this topic that the domestic resource cost is often called the Bruno ratio.

Tables 10-18 and 10-19 illustrate a straightforward approach to estimating the domestic resource cost. This approach is suitable for most project purposes. Its major limitations are the tendency for some "domestic" costs to involve imports—the import consumption of workers, for example—and the partial analysis problem that is common to all discounted measures of project worth. Its advantages are its simplicity and the ease with which the result may be interpreted. To calculate the domestic resource cost by this method, it is necessary to know four items:

Table 10-18. *Calculation of Domestic Resource Cost, Indian Farmers Fertilizer Cooperative Fertilizer Project, India: Foreign Exchange Component*
(millions of US$)

Year	Value of production	Investment cost	Production cost	Other cost or saving[a]	Incremental saving	Discount factor 12%	Present worth 12%
1970	—	7	—	—	− 7	0.893	− 6
1971	—	15	—	—	− 15	0.797	−12
1972	—	15	—	—	− 15	0.712	−11
1973	12	—	12	—	0	0.636	0
1974	38	—	18	—	+ 20	0.567	+11
1975	43	—	20	—	+ 23	0.507	+12
1976	56	—	26	—	+ 30	0.452	+14
1977	56	—	25	—	+ 31	0.404	+13
1978	56	—	25	—	+ 31	0.361	+11
1979–84	56	—	25	—	+ 31	1.483	+46
Total	597	37	276	—	+284	6.812	+78

Source: Adapted from U.S. Government, U.S. Agency for International Development (USAID), "India: IFFCO Fertilizer Project Proposal and Recommendations for the Review of the Development Loan Committee," AID-DLC/P-851 (Washington, D.C., 1969), annexes 4A and 4B.

a. If applicable, would include such differences in cost or saving as foreign exchange for insurance, domestic currency saving in distribution from avoiding port charges and locating production closer to the point of use, and the like.

Table 10-19. *Calculation of Domestic Resource Cost, India Fertilizer Project: Domestic Currency Component*
(millions of Rs)

Year	Investment cost	Production cost	Other cost or saving[a]	Incremental cost	Discount factor 12%	Present worth 12%
1970	107	—	—	107	0.893	96
1971	172	—	—	172	0.797	137
1972	56	—	—	56	0.712	40
1973	24	38	—	62	0.636	39
1974	—	81	—	81	0.567	46
1975	—	90	—	90	0.507	46
1976	—	109	—	109	0.452	49
1977	—	109	—	109	0.404	44
1978	—	109	—	109	0.361	39
1979–84	—	108	—	108	1.483	160
Total	359	1,184	—	1,543	6.812	696

$$\text{Domestic resource cost} = \frac{\text{Present worth of domestic currency cost of realizing foreign exchange saving}}{\text{Present worth of net foreign exchange saving}^{b}} = \text{Rs696} \div \text{US\$78} = 8.92$$

Source: Same as table 10-18.

a. If applicable, would include such differences in cost or saving as foreign exchange for insurance, domestic currency saving in distribution from avoiding port charges and locating production closer to the point of use, and the like.

b. From table 10-18.

(1) the foreign exchange value of the product to be produced; (2) the foreign exchange cost incurred to produce the product (that is, the foreign exchange cost of such things as imported fuels, imported raw materials, and the like); (3) the domestic currency cost of producing the output; and (4) the opportunity cost of capital. The present worth of the net foreign exchange benefit (discounted at the opportunity cost of capital) is compared with the present worth of the domestic cost of realizing these savings. The ratio between the two present worths is the domestic resource cost, and it may be directly compared with the official exchange rate or with shadow exchange rates.

The Indian Farmers Fertilizer Cooperative, Ltd., proposed to build a modern petrochemical fertilizer facility in the state of Gujarat. The economic analysis gives the costs and benefits broken down into their foreign exchange (table 10-18) and domestic currency (table 10-19) components. The domestic resource cost with a 12 percent opportunity cost of capital assumed is Rs8.92 = US$1.

Since the official exchange rate at the time of the analysis was Rs7.50 = US$1, if the official exchange rate is accepted as a true measure of the value of the rupee (and 12 percent is accepted as the opportunity cost of capital), then it would cost more to manufacture through the project a dollar's worth of fertilizer for import substitution than it would to buy the fertilizer from abroad. At the time the analysis was undertaken, however, it was widely considered in India that a foreign exchange premium of at least 25 percent would better reflect the true value of the rupee. This would make the shadow exchange rate Rs9.375 = US$1 (7.50 × 1.25 = 9.375). If this rate is accepted (with 12 percent still the opportunity cost of capital), then it would cost less to produce a dollar's worth of fertilizer than to import it because the domestic resource cost of Rs8.92 = US$1 is a more favorable exchange rate than the shadow exchange rate of Rs9.375 = US$1.

Calculating Measures of Project Worth Using Current Prices

We have often noted that project analyses are usually done at constant prices because the analyst is concerned with the real return to the project when he is looking at the financial analysis and with the real, not monetary, effects of the project when he turns to economic analysis. Thus, it is common practice for the analyst to assume that general inflation will exert the same relative effect on both costs and benefits and to work in constant prices.

Projects can, of course, be analyzed using current prices. If that were done, general inflation would not affect the selection of projects provided that all projects were analyzed using the same assumptions. That is, the same group of projects would be accepted whether the analysis is done on a constant price basis or on a current price basis. Working with constant

prices, however, is the analytically simpler approach because it avoids estimating a rate of inflation and simplifies the computations.

If we use net present worth as the measure of project worth, the amount of the net present worth will be different depending on whether we use current or constant prices (and also on whether we use a shadow foreign exchange rate or a conversion factor to allow for the foreign exchange premium). If we estimate the opportunity cost of capital for the analysis correctly, we will still select the same group of projects to implement. The opportunity cost of capital, however, will be higher by an allowance for inflation. If we use net present worth, we may assume a different rate for inflation for each year if that suits our analytical purpose. There is no easy means to compare the net present worth at current prices to the net present worth at constant prices; the present worth computation must be repeated for each stream of values, and all projects being analyzed must use the same assumptions. A similar comment holds for the net benefit-investment ratio. The value of the ratio will change with changing assumptions about inflation and there is no easy way to compare the net benefit-investment ratio at current prices to the net benefit-investment ratio at constant prices.

In contrast, an internal rate of return calculated at current prices, with a uniform general inflation rate assumed, can easily be converted to the rate of return at constant prices by dividing 1 plus the internal rate of return stated in decimal terms for the current prices by 1 plus the rate of inflation stated in decimal terms. This is illustrated in table 10-20 with the figures from the Ilocos, Philippines irrigation project that were given in table 9-11. If we assume constant prices, the economic rate of return is 18 percent. If we assume a uniform inflation rate of 6 percent throughout the life of the project, then we can derive the incremental net benefit (cash flow) in current prices for any given year by multiplying the incremental net benefit (cash flow) in constant prices for that year by the appropriate compounding factor for 1 at 6 percent. If we determine the internal rate of return for the resulting incremental net benefit (cash flow) stream, we find it to be 25 percent. Dividing this result (in the form of 1 plus the internal rate of return stated in decimal terms) by the assumed inflation rate (also stated in the form of 1 plus the inflation rate stated in decimal terms) gives 1.18—or the economic rate of return of 18 percent we found using constant prices ($1.25 \div 1.06 = 1.18$).

Calculator Applications in Project Analysis

We noted earlier that calculations for project analysis are simply too tedious to be done by hand; however, even the simplest electronic calculators readily available in virtually every nation are sufficient for nearly all calculations needed in project analysis. Indeed, they are the basic computational aid used both by national planning agencies and by international lending institutions. Unfortunately, many project analysts do

Table 10-20. *Internal Rate of Return Computation Using Current Prices, Ilocos Irrigation Systems Improvement Project, Philippines*
(millions of US$)

Project year	*Incremental net benefit (cash flow) at constant prices*[a]	*Discount factor 18%*[a]	*Present worth 18%*[a]	*Compounding factor for 1 at 6%*	*Incremental net benefit (cash flow) at current prices*[b]	*Discount factor 25%*	*Present worth 25%*	*Discount factor 30%*	*Present worth 30%*
1	− 1.09	0.847	−0.92	1.060	− 1.16	0.800	−0.93	0.769	−0.89
2	− 4.83	0.718	−3.47	1 124	− 5.43	0.640	−3.48	0.592	−3.21
3	− 5.68	0.609	−3.46	1.191	− 6.76	0.512	−3.46	0.455	−3.08
4	− 4.50	0.516	−2.32	1.262	− 5.68	0.410	−2.33	0.350	−1.99
5	− 1.99	0.437	−0 87	1.338	− 2.66	0.328	−0.87	0.269	−0.72
6	+ 1.00	0.370	+0.37	1 419	+ 1.42	0.262	+0.37	0.207	+0.29
7	+ 2.37	0.314	+0.74	1.504	+ 3.56	0.210	+0.75	0.159	+0.57
8	+ 3.70	0.266	+0.98	1.594	+ 5.90	0.168	+0.99	0.123	+0.73
9	+ 5 06	0.225	+1.14	1.689	+ 8.55	0.134	+1.15	0.094	+0.80
10	+ 6.43	0.191	+1.23	1.791	+ 11.52	0.107	+1.23	0.073	+0.84
11	+ 6.43	0.162	+1.04	1.898	+ 12.20	0.086	+1.05	0.056	+0.68
12	+ 6.43	0 137	+0.88	2.012	+ 12.94	0.069	+0.89	0.043	+0.56
13	+ 6.43	0.116	+0.75	2.133	+ 13.72	0.055	+0.75	0.033	+0.45

14	+ 6.43	0.099	+0.64	2.261	+ 14.54	0.044	+0.64	0.025	+0.36
15	+ 6.43	0.084	+0.54	2.397	+ 15.41	0.035	+0.54	0.020	+0.31
16	+ 6.43	0.071	+0.46	2.540	+ 16.33	0.028	+0.46	0.015	+0.24
17	+ 6.43	0.060	+0.39	2.693	+ 17.32	0.023	+0.40	0.012	+0.21
18	+ 6.43	0.051	+0.33	2.854	+ 18.35	0.018	+0.33	0.009	+0.17
19	+ 6.43	0.043	+0.28	3.026	+ 19.46	0.014	+0.27	0.007	+0.14
20	+ 6.43	0.037	+0.24	3.207	+ 20.62	0.012	+0.25	0.005	+0.10
21	+ 6.43	.0.031	+0.20	3.400	+ 21.86	0.009	+0.20	0.004	+0.09
22	+ 6.43	0.026	+0.17	3.604	+ 23.17	0.007	+0.16	0.003	+0.07
23	+ 6.43	0.022	+0.14	3.820	+ 24.56	0.006	+0.15	0.002	+0.05
24	+ 6.43	0.019	+0.12	4.049	+ 26.04	0.005	+0.13	0.002	+0.05
25	+ 6.43	0.016	+0.10	4.292	+ 27.60	0.004	+0.11	0.001	+0.03
26	+ 6.43	0.014	+0.09	4.549	+ 29.25	0.003	+0.09	0.001	+0.03
27	+ 6.43	0.011	+0.07	4.822	+ 31.01	0.002	+0.06	0.001	+0.03
28	+ 6.43	0.010	+0.06	5.112	+ 32.87	0.002	+0.07	0.001	+0.03
29	+ 6.43	0.008	+0.05	5.418	+ 34.84	0.002	+0.07	0.000	+0
30	+ 6.43	0.007	+0.05	5.743	+ 36.93	0.001	+0.04	0.000	+0
Total	+129.07	5.517	+0.02		+458.28	3.996	+0.08	3.331	−3.06

Internal rate of return (economic rate of return) at current prices = 25 + 5(0.08 ÷ 3.16) = 25.13 = 25 percent

Internal rate of return (economic rate of return) at constant prices = 1.2513 ÷ 1.06 = 1.1805 = 18 percent

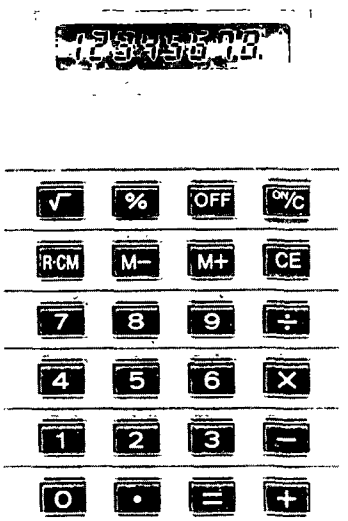
Source: Adapted from World Bank, "Philippines: Appraisal of the National Irrigation Systems Improvement Project: I," 1488a (Washington, D.C., 1977; restricted circulation), annex 20, tables 2 and 6.

a. See table 9-12.

b. An inflation rate of 6 percent is assumed.

not take full advantage of the flexibility that even simple calculators offer.

We will illustrate some of the uses of a calculator in this section. For this purpose we will provide illustrative computations based on a widely sold, inexpensive calculator (see photograph), but the reader should note that calculators do vary in their operation and that these illustrations will probably have to be adapted. The calculator on which this discussion is based has an eight-digit display (indicated by the display window in the photograph). It can perform the four arithmetic functions of addition, subtraction, multiplication, and division. It has one fully addressable memory; that is, one may add to the memory, subtract from the memory, and recall the memory to the display. The calculator can multiply or divide repeatedly by a constant and can perform chain computations. (Although the small calculators generally available are quite accurate, the last two places when the display is fully used following multiplication or division cannot be accepted with confidence. All the digits reproduced in the computations below are correct because they have been verified with more elaborate equipment; when the reader follows these illustrations on his own calculator, he may find occasions when the final digit or two do not agree with those given here.)



In these illustrations, numbers reproduced in ordinary roman type are pressed and entered on the calculator as indicated. Numbers printed in *italic* type will be displayed automatically and do not need to be entered. An arithmetic sign or a function notation in **boldface** type indicates that this key (button) on the calculator is to be pressed in the order shown. Thus, a 2 indicates a number to be entered and a **+** indicates that the plus button should be pressed. Other notations include **M+** for "add to memory"; **M−** for "subtract from memory"; **R·CM** for "recall memory" when pressed once and "clear memory" when pushed a second time; and **ON/C** for turning the machine on and for clearing the display.

We can illustrate the arithmetic and chain calculations quickly and simply. Recall the example about calculating the economic value of a tractor in chapter 7 (the subsection "Adjusting Financial Prices to Economic Values. Indirectly traded items"). We discussed the various computations needed to go from a market price to an economic value. We were told that in a tractor costing Rs65,000, 30 percent of the cost was for domestic components and 70 percent of the cost was for imported components. There was a tariff of 15 percent, so the amount of the imported component had to be divided by 1.15 to eliminate the tariff. We wanted to shadow-price the imported component by using a shadow exchange rate

of Rs12 = US$1 instead of the official exchange rate of Rs10 = US$1, and this meant that we increased the domestic price of the imported component by the foreign exchange premium of 20 percent, or 1.2 stated in decimal terms. Each step was set forth individually, but we could have combined all the computations into one chain calculation:

R-CM R-CM 65,000 **x** 0.3 **M+** *19,500*
65,000 **x** 0.7 ÷ 1.15 **x** 1.2 **M+** *47,478*
R-CM *66,978.*

The last figure is, of course, the amount we derived when we added the individually calculated portions together.

One very convenient use of a simple calculator is to verify budget tables quickly. In the Paraguay farm budget in table 4-19, during the fourth year the total inflow was ₲426.6 thousand and the total outflow was ₲129.3 thousand, and these gave a net benefit before financing of ₲297.3 thousand. From this was subtracted debt service of ₲98.2 thousand to obtain the net benefit after financing of ₲199.1 thousand. We can quickly check these totals by simply entering the individual inflow and outflow entries in order on the calculator:

R-CM R-CM 340.7 + 85.9 **M+** *426.6*
13.4 + 112.8 + 3.1 **M–** *129.3*
R-CM *297.3*
ON/C – 98.2 **M+** – *98.2*
R-CM *199.1.*

The use of the constant feature of the calculator is convenient when we have several values we wish to change by some common proportion. In the calculator we are using for illustration, the constant feature is activated after multiplication and division simply by entering a new number and pressing the = button, but on many calculators the constant feature is activated by pressing the "arithmetic" button twice before pressing the = button. An example of when the use of a constant would be convenient is found in table 7-1, in which we wished to convert all dollar values to their rupee equivalents using a shadow exchange rate. We have dollar values of US$175, US$20, and US$9. The shadow exchange rate is Rs12 = US$1:

R-CM R-CM 12 **x** 175 = *2,100*
20 = *240*
9 = *108.*

One use of even a simple calculator that also takes advantage of the constant feature is to derive the factors for financial computations or for discounting. Suppose we want to find the compounding factor for 1 for 14 percent at the end of five years:

1.14 **x** 1 = = = = = *1.925 414 6.*

We can verify this by checking in a standard set of tables such as *Compounding and Discounting Tables for Project Evaluation* (Gittinger 1973). Note that in laying out the computation as indicated the = button is

pressed as many times as the number of years to be calculated, in this case five.

Discount factors can be just as easily calculated. Since we know that the discount factor is the reciprocal of the compounding factor for 1, we could find the discount factor for 14 percent for five years by dividing 1 by 1.925 415 to obtain 0.519 369. We could reach this result more directly by using our calculator to divide 1 repeatedly by 1 plus our discount rate to obtain the discount factor for 14 percent for five years:

1.14 ÷ = = = = = *0.519 368 7.*

Again, we may verify this by checking in the tables or, to the nearest third decimal, in compounding and discounting table 6 in appendix B.

Since the present worth of an annuity factor is the running subtotal of the discount factors, we may obtain it by adding together all the discount factors as we compute them. On the least expensive calculators, there may be an accumulating memory that makes this very easy. On the somewhat more complicated calculators with fully addressable memories in which the **M+** activates the constant feature, the computation is also simple. But on the calculator we are using for illustrative purposes, a bit more manipulation is required. Suppose we want the present worth of an annuity factor for 14 percent for five years:

R-CM R-CM 1.14 ÷
= M+ = M+ = M+ = M+ = M+
R-CM *3.433 081 0.*

Finally, we may compute the capital recovery factor easily if we recall that it is the reciprocal of the present worth of an annuity factor. Since we have already obtained the present worth of an annuity factor for 14 percent for five years, we could simply divide 1 by 3.433 081 to obtain 0.291 284. We could compute this directly, however:

R-CM R-CM 1.14 ÷
= M+ = M+ = M+ = M+ = M+
R-CM ÷ = *0.291 283 5.*

For project analysis, the ease with which we can compute discount factors using a simple calculator is most significant when we have occasion to use a fractional discount rate. Some standard discounting tables (including Gittinger 1973) do not have fractional intervals, and those which do generally do not have them for higher interest rates. Using a simple calculator, however, we can easily compute our own factors if, for example, we want to calculate a present worth at some fractional discount rate.

In agricultural projects, one use of the calculator to derive factors occurs when we are working out debt service estimates in farm budgets where the credit terms involve fractional interest rates. In the India Cashewnut Project used to illustrate unit activity budgets in chapter 4, tables 4-22 and 4-25, farmers could borrow at 10.5 percent interest to finance tree planting and then repay in six equal annual installments. To calculate the annual payment for years 8 through 13, we need the capital

recovery factor for 10.5 percent for six years. We are unlikely to be able to find the factor in a standard discounting table, but we can easily obtain it directly by using our calculator:

R-CM R-CM 1.105 ÷
= M+ = M+ = M+ = M+ = M+ = M+
R-CM ÷ = *0.232 981 9.*

Without a fractional discounting table, we cannot verify our result directly, but we can check to make sure it is of the right order of magnitude by comparing it with the capital recovery factor for six years for 10 percent and for 11 percent. For 10 percent the value is 0.229 607; for 11 percent it is 0.236 377. Our capital recovery factor lies roughly halfway between these two values (although not exactly so, of course), so we may be confident that our factor is pretty close to correct. Now, we may multiply the loan principal (including capitalized interest) of Rs4,756 by our factor of 0.232 981 9 to obtain the annual payment of Rs1,108 (4,756 × 0.232 981 9 = 1,108). This, then, is the amount shown for debt service in years 8 through 13 in tables 4-22 and 4-25.

The various factors used in project analysis may also be computed directly quite easily if one has a calculator that can compute powers. (The simple one we have been using for illustration cannot.) Usually this is indicated by a key marked with $\mathbf{x^y}$ or some similar notation. If we return to the example from the Indian credit project noted above, we may illustrate how to calculate directly the capital recovery factor for 10.5 percent for seven years. The formula for the capital recovery factor (given in appendix B) is:

$$\frac{i(1+i)^n}{(1+i)^n - 1}.$$

For convenience, we will begin by calculating the denominator first and then put it into the memory. It is also convenient to begin our calculations by determining the value of $(1 + i)^n$ and then subtracting 1:

R-CM R-CM 1 + 0.105 = *1.105*
1.105 $\mathbf{x^y}$ 6 = *1.820 428 7*
1.820 428 7 − 1 = *0.820 428 7* **M+**.

Now we may calculate the numerator. Since we know from our previous calculation that the value of $(1 + i)^n$ is 1.820 428 7, we may begin with that value and then multiply it by i, or 0.105:

1.820 428 7 **x** 0.105 = *0.191 145 0.*

Proceeding, we may divide 0.191 145 0 by 0.820 428 7, which has been stored in the memory, to obtain our capital recovery factor:

0.191 145 0 ÷ **R-CM** *0.820 428 7* = *0.232 981 9.*

This is the same factor we computed before using the much simpler calculator without the $\mathbf{x^y}$ key.

Rather more elaborate calculators than those we have been discussing

here also have a role to play in project analysis. Calculators designed for business use are available that calculate present worth or even internal rate of return directly from a series of numbers keyed into the calculator. Hand-held calculators programmable with magnetic cards have many potential applications. In agricultural projects they may be used to calculate farm budgets and—most conveniently—herd projections (Espadas 1977). A herd projection that may take even a skilled livestock specialist eight hours to calculate using a simple calculator can be prepared in one or two hours using a card-programmable calculator. The implications for sensitivity analysis are obvious.

The use of computers (as opposed to calculators) in agricultural project analysis is still limited, but the use of "minicomputers" is spreading rapidly, and programs for agricultural project analysis are being developed by the Food and Agriculture Organization and the World Bank. One well-known application of large computers is to optimize cropping patterns using linear programming (see Norton and Solis 1982), but this has been limited for the most part to research efforts and has not become common in operational project evaluation. Computer programs are available for herd projections (Powers 1975). The Inter-American Development Bank has published a computer program to appraise farm development projects (Westley 1981). The Food and Agriculture Organization has developed a program for project analysis that is suitable for small computers. A recently developed World Bank program called Computerized Project Analysis Support System, for which the acronym COMPASS has been adopted, is available for use by project analysts who have access to larger computers. The program can prepare pattern farm budgets, develop project cost tables, do financial analyses of nonfarm enterprises, and elaborate other tables unique to the individual project analysis. From these components it can then aggregate to the project cash flow, calculate measures of project worth, and perform sensitivity analyses. One very convenient use of large computers is for "table making." Programs are available that accept information, arrange it, perform calculations with the data supplied, and then print the result in the form of a table that may be photocopied and included directly in a project report. Information about computer programs for project analysis may be obtained by addressing the Director, Information Resource Management Department, World Bank (Washington, D.C. 20433, U.S.A.).

Appendixes

Appendix A

Guidelines for Project Preparation Reports

THE GENERAL GUIDELINES in this appendix are intended to give an idea about the scope and content of a preparation or appraisal report for an agricultural or rural development project. Most projects in agriculture and rural development are adaptable to a fairly standard form of presentation. The format outlined here can provide the analyst with a starting point. It will give the readers of the report a narrative with supporting tables and annexes that succinctly convey the information necessary for them to form their own conclusions about the worth of the proposed project without confounding them with unnecessary or extraneous detail.

These guidelines emerge from the combined experience of the Food and Agriculture Organization (FAO), the World Bank, and other international lending institutions. They are adapted, often verbatim, from materials prepared by the FAO Investment Centre for the use of project analysts in developing countries and its own specialists (FAO 1975 and 1977). In addition, the Investment Centre has prepared a series of specialized guidelines for particular kinds of projects, which are available from the center on request. A comprehensive set of outlines for many different kinds of agricultural projects has also been prepared by the Inter-American Development Bank (1978).

Facing page: Picking maize in Guatemala.

Clearly, the substance of a project preparation report is more important than its format. Obviously, too, different elements of a report will need different emphasis depending on the kind of project. The analyst will want to vary the format given here according to the type and complexity of the project he is presenting. On the one hand, these general guidelines touch on many more topics than are needed for any but the most complex project, and the topics mentioned tend to overlap. On the other hand, topics essential to understanding many kinds of agricultural projects have been omitted. This is especially true for projects with significant marketing and processing, rural industry, and rural road components. The analyst will want to leave out topics addressed in these guidelines that are not essential to an understanding of the particular project and to include additional topics that are critical to forming a judgment about the project at hand. He will want to deal with any of the relevant topics in only one place in the report so as to avoid excessive repetition.

As a rule of thumb, a project report should aim at a main text of about twenty-five single-spaced typescript pages for a straightforward agricultural project and of no more than fifty pages for a complex rural development project. This should be supported by a series of annexes, possibly in a separate volume and reproduced in fewer copies. Worksheets, detailed assumptions, and the like may be gathered into a project file and kept at some central location where anyone interested may find them. As far as possible, the main text should present the project in a form that a nonspecialist can understand; specialized back-up information—including maps, charts, and detailed tables—should be reserved for the annexes or the project file.

The principal elements of a project preparation or appraisal report are outlined in the following pages in the order in which they normally appear.

1. Summary and Conclusions

The main purpose of this part, generally only a page or two in length, is to give the reader the essential elements of the project very briefly. It should cover the rationale of the project and its priority, purpose, location and size, beneficiaries, main components, investment period, costs, organization, financial and economic effects, and main issues.

2. Introduction

This part, which is a nontechnical one, usually mentions the arrangements through which the project report was prepared. It can indicate the origin of the project concept in the national development plan, in a sector survey, or by a project identification mission. It might mention the government agencies and other organizations involved in the prepara-

tion and any external assistance received. It can acknowledge the team that prepared the project and the report and can mention the period in which they worked. None of the information needs to be given in much detail.

3. Background

To the greatest extent possible, background material should be annexed to the report. A well-thought-out and properly constructed background discussion, however, can do much toward establishing the framework of the project and making it intelligible in a broader economic and social perspective. The analyst needs to be very discriminating when choosing material for this part. The only general guidance is that there should be a clear relation between this material and the contents of other sections of the report. The tendency to ramble is usually more pronounced here than in other parts of the report.

3.1 *Current economic situation*

This discussion could mention per capita income, dependence on particular imports and exports, balance of payments considerations, and the like. It should cover only those features of recent economic developments that have a bearing on the project and on studies of the possible alternatives to the project.

3.2 *The agricultural sector*

This section might describe the main characteristics of the agricultural sector of the country, including constraints to overall development and a description of relevant subsectors.

3.3 *Development and social objectives*

This section might outline development and social objectives as expressed in national plans and official policy statements. It could note the main elements of the national strategy for agricultural development and mention significant government policies, including price and interest rate subsidies, supply of inputs, targets for rural income, regional balance, and the like.

3.4 *Income distribution and poverty*

If a project is designed to benefit a particular group of the rural poor, a discussion of income distribution and poverty would be appropriate in the background section. The information should establish a framework for the eventual justification for selecting a particular region or line of action for priority attention under the project. It should cover informa-

tion about income distribution on a national basis and give a regional or social dimension to the data.

3.5 *Institutions*

This paragraph might describe the institutions concerned with development and financing in the sectors covered by the project. These might include the ministry of agriculture, the agricultural development bank, the livestock development authority, and the like.

4. Project Rationale

This part should make a persuasive argument for selecting this project for priority attention. Against the background of the previous part, it should fully discuss the development opportunities and constraints within the relevant sectors. It should also explain why a particular development strategy has been decided for this project and establish the technical, social, and economic reasons for the selection of this particular project in preference to possible alternatives. This may also be the best point at which to indicate the scale of the proposed project and to explain why a certain size has been chosen. Finally, there should be a discussion of the project risks and the steps that have been taken in project formulation and that should be taken in project implementation to minimize them.

5. Project Area

The objective of this part, and the details in the supporting annexes and maps, is to present a description of the existing status of the area where the project will be located and to give the basis from which the project starts. These descriptive data should be presented in the relevant physical, agricultural, social, economic, institutional, and legal terms. The part should evaluate, in a narrower sense than the discussion of the agricultural development strategy and the project concept, the development opportunities and potentials as well as the limitations the area presents, focusing throughout on the project description that follows.

5.1 *Physical features*

This section will deal with the main geographical and topographical features of the area and relate the area to important features of the country as a whole. The principal objective is to show that the climate and soils are suitable for the crop and livestock production proposed.

5.1.1 GEOGRAPHICAL LOCATION. The general location of the project area within the country is identified, and then the area is defined more pre-

cisely in relation to administrative boundaries and other criteria. The project area might, for example, be a province, a district, a watershed, the command area of a dam, or a combination of these. A tree-crop rehabilitation project might be concerned with particular estates or plantations. Some projects will concern only farmers who produce particular crops but may be spread over a large area.

5.1.2 CLIMATE. This section should cover rainfall, including monthly and annual totals, intensity and variability, temperatures, humidity, evapotranspiration, and the like. Available records and more technical information may be summarized in the annexes. For a dryland farming project, the objective is to show that the amount and timing of rainfall is appropriate for the cropping pattern proposed. For irrigation projects, the rainfall record supports conclusions about when irrigation water is needed and in what volume.

5.1.3 GEOLOGY, SOILS, AND TOPOGRAPHY. Information in this section should support conclusions about the land in the project—its agricultural potential, its suitability for irrigation, its needs for drainage, and the like. Judgment will be required about the scale of the maps of soil and land classification to be included in the report. In project preparation, detailed maps will be needed; in the annexes to the preparation or appraisal report, simply a reference to the detailed maps (kept on file) and a summary map of quite small scale may suffice.

5.1.4 WATER RESOURCES. Surface and underground water resources should be described to the extent they are relevant to project decisions. Usually this is done from the viewpoint of irrigation and drainage, but it may also have a bearing on provision of water for domestic use.

5.2 *Economic base*

This section should cover the main economic features of the project region. It may tend to overlap with some of the social aspects in the following section (5.3). Duplication, of course, should be avoided.

5.2.1 AGRICULTURAL AND LIVESTOCK RESOURCES. The agricultural and livestock resources of the region should be described briefly and the major features quantified. The importance of these sectors in the economy of the region, the proportion of people employed in these activities, the area and output of major products, and an approximate estimate of the value of these products may be given. Recent trends should be noted, and the relative importance of the sector to be assisted under the project should be emphasized.

5.2.2 LAND USE, FARMING SYSTEMS, AND CROPPING PATTERNS. The present land use should be described. This will include information about land tenure, farm size, cropping patterns, crop varieties and livestock breeds, crop yields and livestock production, and inputs. Much of this material

can be presented in tabular form in the annexes and only a commentary given in the main text. A short description of agricultural practices and level of technology for each main farming system may be in order. Results achieved on experimental stations in the area may be mentioned, and the performance of individual farmers who have tested the proposed system can be noted to indicate potential production. Constraints should be clearly described, including such factors as social customs, land tenure, technical shortages, and lack of extension that might prevent farmers from reaching acceptable production levels.

5.2.3 INPUT SUPPLY AND PRODUCT MARKETING. A concise description should be given of existing channels for the supply of inputs and of the facilities for marketing farm production. The effects of such government policies as price supports, input subsidies, taxes on products, and the like may be described and evaluated.

5.2.4 OTHER ECONOMIC ACTIVITIES. There may be other economic activities in the area that are important to an understanding of the project. These may include forestry, fishing, rural handicrafts, and processing industries. If data are available, the number of families engaged in secondary activities may be indicated, with at least an approximate indication of their importance to the rural economy.

5.3 *Social aspects*

Social features of the project area should be described under appropriate subheadings. Many topics will overlap with other sections, and a decision will have to be made about where in the report to treat certain topics to avoid duplication.

5.3.1 LAND TENURE AND SIZE OF HOLDINGS. When land tenure is particularly important in a project or where extensive changes are contemplated, it may be more relevant to include land tenure with the discussion of the social aspects than with the discussion of land use (5.2.2). Land tenure should be discussed with reference to the proportion of owner-cultivators, tenant cultivators, and landless labor. If possible, the size of holding may be related to the kind of tenure. The descriptions should refer to any changes in land tenure caused by agrarian reform or settlement.

5.3.2 POPULATION AND MIGRATION. Data may be given that illustrate such aspects of population as density per square kilometer, pressure of population on the cultivated area, dependency ratios, and the literacy rate. It may be relevant to define the rural population, since towns in the project area may be more like large rural villages than small urban centers. When migration is important, annual or seasonal flows may be described and, if possible, quantified. If rural-urban migration is an important issue, its significance and extent may be discussed. A discussion of labor supply may be important if proposed cropping patterns depend on hired labor. A discussion of unemployment and underemploy-

ment in the project area or nearby and its seasonality may be relevant. Income levels will have been referred to earlier, but the discussion of the social aspects may include more detailed information about the project area and about other indicators of the quality of rural living such as housing, health, and nutrition. A population projection for the project area over the project life may be included, as well as a discussion of the implications this may have for the project.

5.3.3 SOCIAL SERVICES. When it is important to an understanding of the project and the reasons for its selection, the social services available in the area may be discussed. These services may include primary and secondary schools, dispensaries, and other facilities. Disease problems in the area and possibilities of their control may be discussed. Mention should be made about which social services function well and which may need improvement.

5.4 *Infrastructure*

The treatment given to infrastructure will depend on the extent to which the project itself will have infrastructure-related components. Some projects are concerned exclusively with providing rural infrastructure, in which case, of course, the weight given to this section would be substantial. It may be relevant to quantify the total length of project roads, annual tonnage moved, recent growth in traffic, and the like. The relevance of infrastructure to marketing of project output and to the supply of inputs should be mentioned. Water and electricity services within the region may be briefly described. The number of families served by various infrastructure facilities may be quantified. Ongoing improvement programs may be briefly evaluated.

5.5 *Institutions*

This section, which supplements the discussion of the national situation in the background part of the report (3) should describe the local activities of national agencies or of any special institutions, such as local development authorities, operating in the project region. The main purpose of the section is to provide a basis for understanding the proposals about organization and management of the project that are outlined later. The reader of the report will want to know which institutional arrangements are working satisfactorily and which will need supplementary attention under the project.

6. The Project

Previous parts having set the framework of constraints and opportunities for the project, this part and its supporting annexes should define and describe in detail the objectives of the project and its works and activities—their phasing, their costs, and how they will be financed and pro-

cured. As always, the emphasis on particular elements outlined below will vary with the nature of the project, and topics not mentioned may be essential to an understanding of the project. The analyst should adapt this part especially to fit the project.

6.1 *Project description*

This section should give a brief overview of the objectives, location, size, components, and other important features of the project. It serves simply to suggest to the reader of the report what to expect in the more detailed sections that follow. Three or four paragraphs should suffice.

6.2 *Detailed features*

The objective of this section is to describe the proposed project works and other components that make up the project item by item and category by category. It should concentrate on the technical aspects and describe what is to be done in sufficient detail to establish the nature, scope, and cost of the various measures proposed. It should be backed, where necessary, by supporting annexes. Consideration of the costs of implementing the measures is taken up in the section about project costs (6.4), and the manner of implementing them is outlined in the part that discusses organization and management (7), but cross references here may be helpful.

6.2.1 WORKS AND GENERAL FACILITIES. This section includes discussion of irrigation facilities, general infrastructure for settlement projects, access roads, extension facilities, and social infrastructure such as village water supplies, health clinics, schools, and rural electrification. If a development authority is responsible for undertaking construction work, a list of equipment needed for the project may be included here. Similar provision may be made for equipment for operation and maintenance of project works.

6.2.2 ON-FARM INVESTMENT. This section will discuss items such as fencing, farm irrigation and drainage systems, land clearing and leveling, pasture development, and the like. The distinguishing feature of such works is that they are normally carried out by farmers or at the expense of farmers on their own farms, with the project making available credit and perhaps arrangements for the work to be carried out. They are best illustrated by farm budgets that represent the kinds of cropping patterns and livestock enterprises to be undertaken. Farm budgets are also important to the discussion of farm income (8.3) and elsewhere in the project report. As suggested in the discussion of farm income in section 8.3, a centralized analysis is desirable; this probably should be given in an annex.

6.2.3 FARM BUILDINGS AND EQUIPMENT. This section discusses irrigation pumps, sprayers, on-farm storage facilities, tractors, livestock sheds, and

a wide range of similar items that in general are made available to farmers through credit arrangements.

6.2.4 CREDIT PROGRAM. If credit is to be provided as part of an overall project, it may conveniently be discussed at this point. This discussion may include the required total amount of credit derived from aggregating farm budgets and the applicable credit terms. If the project is predominantly one to provide credit, only a discussion of the totals involved may be needed here. Detailed discussion of the credit program may be reserved for the section on credit administration (7.1) and the specialized annexes.

6.2.5 PROCESSING AND PRODUCT-MARKETING FACILITIES. Processing and marketing facilities needed under the project may be described in this section. If processing facilities are a large component of the project, this section may be limited to a general description. The detailed discussion can be concentrated, as appropriate, in the sections devoted to marketing structure (7.2), to availability of markets (8.2), and to processing industries and marketing agencies (8.4). As is the case with farm budgets and discussion of a credit agency, a separate annex with detailed accounts for processing and marketing enterprises and with a full discussion of organizational and other problems may be desirable.

6.2.6 SUPPORTING SERVICES. Special supporting services included in the project may be described here. Of particular importance is provision for extension. The number, grade, and availability of additional extension officers may be mentioned, as may their requirements for transport, office equipment, and housing. If the project includes components to train staff or farmers, the relationship of these to national facilities may be described and any facilities such as classrooms and dormitories outlined.

6.2.7 SOCIAL SERVICES. Any social services envisioned under the project should be included in the description of the detailed features. Health services and disease control may be important project activities. The particular actions anticipated should be described and quantities given if new staff or facilities are needed. If education is a project component, the new schools should be described and the number of pupils foreseen given, along with the number of teachers needed. A discussion of domestic water facilities and the number of households involved may be in order.

6.3 *Project phasing and disbursement period*

This section should describe in detail the phasing of the proposed project actions, including works and general facilities, farm development, processing and marketing facilities, supporting facilities, and social services. From this section are derived the justification for the phasing of expenditure and the disbursement pattern of any loan envisioned

for the project. In most cases the disbursement and development periods of agricultural projects extend over three to five years, and this section should address this time horizon. Some projects, such as those involving tree crops, entail a longer phasing and disbursement period. This section might be supported by an annex containing a detailed graphic presentation such as a "critical path diagram" to indicate the sequence of project activities and which activities cannot be delayed without delaying the whole project. [For a discussion of critical path diagramming, see Mulvaney (1969).]

6.4 *Cost estimates*

The importance of accurate cost estimates cannot be overemphasized. They are a crucial element in determining the financial and economic viability of the project and also for planning its funding. The main text should give aggregate cost in a summary table; the complete cost breakdown can be given in annexes. There are many ways to group costs, but a common one is to distinguish between capital and recurrent costs. Costs should be broken down to show local and foreign exchange components. The foreign exchange component includes expenditure for both directly and indirectly imported goods and services. Costs in this section would be presented in constant financial, not economic, terms, and they would be shown at market prices. Duties and other taxes would also be shown, but these should be separately indicated, at least in the annexes. Current costs would be given as part of the financing plan (6.5.4).

6.4.1 CAPITAL COST. The headings under which capital cost is summarized and discussed in the main report preferably should correspond to the approach adopted for the physical description of the items. The estimate for civil works should be based on unit rates and quantities. If equipment for construction or operation and maintenance will be procured under the project, the cost of these should be shown separately. The cost of on-farm development works is determined by aggregation from the pattern farm budgets. Often only those items to be financed by credit, or the amount of the credit needed, will appear in this section. To aggregate from the farm budgets to the economic cost of the project, however, the full incremental cost incurred by the farmers will be needed. If land is acquired for project purposes and a cash outlay is required, this outlay should be included in the items of capital cost. But if the government provides the land free of cost, land will not be included as a project cost item; the opportunity cost of the land, however, will be allowed for in the economic analysis.

6.4.2 RECURRENT COSTS. Either in this section or in the section devoted to financing (6.5), provision will have to be made for the recurrent cost needed for project operation. Recurrent cost usually refers only to the budget for the proposed executing agency.

6.4.3 CONTINGENCIES. It is common for the cost estimates to include a physical contingency allowance, usually on the order of 10 or 15 percent. Price contingency allowances are covered in the section on financing (6.5) or in the section on the budget of the government operating agency or project authority (8.5).

6.5 *Financing*

It is important to prepare a financing plan for the project so that the government may be fully aware of the immediate and future budgetary implications of the project. The plan may be summarized in tabular form in the main text of the report, and supporting detail may be included in the annexes or in separate documents. Completion of the full financing plan may need to await completion of negotiations with outside financing agencies, but it may be possible to include in the preparation report totals of at least the most important items, with the notation that some sources of financing remain to be determined. Some of the elements of the financing plan will grow directly out of the project preparation. For example, when the analyst draws up the credit program, a decision will have to be reached about the down payments to be made by farmers and the rate at which they will be required to repay their loans. Similarly, estimating the foreign exchange component of the project tends to put a ceiling on the proportion of total cost to be met by an outside financing agency.

6.5.1 INVESTMENT COST. The amounts needed by the project each year during the investment phase (or disbursement phase, if outside financing is involved) should be tabulated by major category and broken down into domestic currency and foreign exchange. When known, the proportion of total cost to be borne from domestic sources and that to be financed from outside may be indicated.

6.5.2 TAX REVENUE. If the project will generate significant new tax revenue, as might be the case if the project will increase production of a crop on which an export tax is levied, the amount and timing of the new revenue should be detailed.

6.5.3 RECURRENT COST. A projection should be made of the recurrent cost necessary to operate the project once the investment phase and any anticipated receipt of foreign financing ends. This will indicate the continuing burden on the treasury of maintaining the project administration. This projection will need to be related to the section on the budget needs of the project executing agency (8.5) and to the policies outlined in the section on cost recovery (8.6). The net burden allowing for any increased tax revenues may be noted.

6.5.4 CURRENT COST. Since the project cost normally is stated in constant terms, the financing plan should address itself to a tabulation of the investment and recurrent cost in current terms once the project is undertaken. This will become the basis for the budget allocation as the project proceeds. Since this may involve making a politically sensitive judgment about future rates of inflation, this part of the financing plan may appropriately be dealt with in a separate memorandum addressed to the ministry of finance.

6.6 *Procurement*

Special requirements for procurement may be mentioned in this section. If it is contemplated that financing will be sought from an international lending agency, special procurement regulations may have to be noted.

6.7 *Environmental impact*

Nations are increasingly concerned about the environmental impact of proposed projects, and decisionmakers will want assurances that proper attention has been paid to environmental considerations and that any adverse ecologic effects have been minimized. If a significant environmental impact is likely, full treatment in an annex may be called for; otherwise, a short explanatory paragraph will suffice.

7. Organization and Management

In general, the part on organization and management is intended to show which entity or entities will be responsible for the various aspects of project execution and operation and how these entities will carry out their responsibilities. The discussion should demonstrate that the executing agencies have adequate powers, staffing, equipment, and finance. It should show that there are adequate arrangements for coordination between and within the administrative groups responsible for the various project activities. If there are deficiencies, the changes and improvements required should be clearly stated.

For each administrative group, this part of the report should give details of legal status, functions and powers, internal organization, staffing, and the like. If the administrative agency is not a government department, it may be desirable to give details about the legal charter and governing board, how the board is appointed, and any special provisions concerning its budget.

When there is more than one agency concerned with a project, the arrangements for coordination, joint representation on boards, joint committees, and joint use of field facilities may be described.

This part should address the ability of the senior management of an implementing agency to decide policies, approve important expenditures, and appoint the project management responsible for day-to-day operations. It should discuss the number and caliber of the project staff and whether their assignment will permit them to devote enough time to the operation of the project. The qualification and experience of the key management staff may be noted either in an annex or in a separate memorandum. The needs of the project for professional technical staff and the expected availability of such staff should be mentioned. Arrangements for recruitment and staff training should be described. Any necessary provision for assistance from expatriates should be noted and details about the qualifications of expatriates given.

Projects with special emphases will require a discussion of the organization and management requirements imposed by the nature of the particular projects. Several of these special requirements are noted in the following sections. In some instances, a detailed discussion in the annexes will be appropriate.

7.1 *Credit administration*

If credit is important in the project or if the project is predominantly an agricultural credit project, particular attention must be paid to the administrative capability and financial status of the credit agency. In the main text only a summary statement may be necessary, but in the annexes it may be desirable to go into considerable detail. Such details should include projected accounts for the credit agency and a thorough analysis of the position of the agency concerning arrears in repayment of loans and interest delinquencies. Other points to be considered are the legal charter, capitalization, powers and functions, direction, management, delegation of authority, internal organization, staffing, accountancy and control, auditing, operating policies, terms and conditions of loans, collateral requirements and their appropriateness for the group the project is intended to benefit, procedures for loan appraisal and disbursement, and the capability of the agency to operate in a timely and effective manner in the project area. Arrangements for administrative improvements and staff training should be mentioned.

7.2 *Marketing structure*

In this section the organizational arrangements, both public and private, for marketing farm production should be described and assessed. Particular attention should be paid to any rigidities or insufficiencies, and to proposals for correcting the situation if these inadequacies are relevant to the project. A separate annex discussing marketing institutions and proposals to improve them may be desirable if marketing is an important component of the project. This section should be related to that dealing with the financial effects of the project on processing industries and marketing agencies (8.4).

7.3 *Supply of inputs*

This section should discuss the responsibility and arrangements for the provision of supplies for farm production and should mention proposals, where necessary, for improved supply of such inputs. If labor availability was not discussed in the section on population and migration (5.3.2), it may be appropriate to address the question here.

7.4 *Land reform*

If the project will involve any change in land tenure or distribution, the agency responsible for such matters should be described and assessed. There should be a discussion of relevant land laws, cadastral aspects, conditions of tenure, and—in settlement projects—farm size and selection of settlers. Particular attention should be paid to the timing and implementation of land reform measures.

7.5 *Research*

If new research or additional field trials are to be needed, the arrangements and staffing should be discussed. If expatriate specialists will be needed, their qualifications and responsibilities should be outlined. Plans for staff training should be mentioned.

7.6 *Extension*

The arrangements to bring new information about production to farmers in the project area should be discussed. Special equipment and facilities should be outlined and justified unless they have been dealt with in the section on supporting services (6.2.6). Staff training, especially for field agents in the project area, should be outlined.

7.7 *Cooperatives*

If it is intended that cooperatives will be used in the project, the relevant legislation, organization, structure, and operating record of the cooperatives and the agencies responsible for encouraging or administering them should be discussed. Proposed measures for development of cooperatives in the project area, including staff training, should be described.

7.8 *Farmer organization and participation*

The responsibility for any other measures to encourage farmers' participation in the project, to establish farmers' associations, and to ensure good relations between farmers and the project administration should be discussed.

8. Production, Markets, and Financial Results

By the time the reader reaches this point in the project report, much ground will have been covered: the national setting for the project and the reasons for its selection; the project itself, including its technical aspects and costs; and the proposed manner of implementation. From here onwards, emphasis is on the financial and economic feasibility of the project. The report should show that the results of project actions will be sufficiently attractive financially to encourage enough farmers to participate. For processing industries or marketing agencies, the report should demonstrate that it will be financially viable for such firms to participate in the project and that their financial return will be sufficiently attractive.

8.1 *Production*

The primary benefit of an agricultural or rural development project is usually incremental output from project farms. This is generally the basis on which the project is formulated in the first place, and the physical results to be expected are illustrated in the farm models. Project actions may permit introduction of completely new and more valuable crops but more often will be directed toward increasing yields of existing crops or permitting a more intensive form of livestock production. In any case, the assumptions about yield or livestock production, both with and without the project, should be fully supported in the annex materials.

In this section, attention should be directed toward the aggregate increase in production that is expected. Account should be taken of such factors as the number and phasing of the farms included in the project and the build-up of average yields as farmers adopt the improved technology or as new plantings of tree crops approach maturity. A table showing aggregate build-up during the development period of the project may be included in the annex.

8.2 *Availability of markets*

This section should demonstrate that satisfactory markets exist for the product of the project. The market must be of sufficient size to absorb the production proposed for the project. If the scale of the project is large enough to exert an appreciable influence on the market, this effect will probably require fairly detailed treatment in an annex, but only the salient points need be mentioned in the main text. If an export commodity is involved, attention should be paid to such special situations as preferential treatment, long-term contracts, or quality preferences. Domestic pricing policies should be fully covered, either in the main text or in a special annex, if they are a matter of extensive debate or if significant policy changes will be required for the project. This section

will also mention prices for internationally traded commodities and summarize the results of the import and export parity price calculations that are given in more detail in annex text and tables.

8.3 *Farm income*

The effects of the project on farm income are demonstrated through presentation of farm budgets such as those outlined in chapter 4. Because farm budgets are fundamental to any agricultural or rural development project analysis and will also have been referred to in connection with on-farm investment (6.2.2) and the topics of other sections, it is important to present a fully developed analysis in the project report. This probably can be most conveniently done in one annex, which should include farm budgets that indicate the inflow and outflow for each major farm model anticipated in the project, outline financing needs, and project the incremental net benefit the farm family may expect.

8.4 *Processing industries and marketing agencies*

A discussion of the financial effects of the project on processing industries and marketing agencies may be in order if the project contains such components. A summary in the main text may suffice, but detailed projections of balance sheets, income statements, sources-and-uses-of-funds statements, and the incremental cash flow should be included in appropriate annex material along the lines discussed in chapter 5.

8.5 *Government agencies or project authorities*

In some project reports, especially if the project is to be administered by a largely self-supporting project authority, an analysis of finances from the standpoint of the administering agency may be in order. This section could include expected inflows and outflows of the project authority and the government budget amounts required to support the project. It should be related to the cost recovery section below (8.6). Annex materials along the lines suggested in chapter 6 may be included. Care should be taken to avoid duplication with the section on financing (6.5). In some reports, it may be desirable to centralize the financing plan here and simply to cross-reference it in the section on financing. In any case, if much detail is to be included it may conveniently be gathered into an annex to which both sections can refer.

8.6 *Cost recovery*

This may be an appropriate point in the report to mention any arrangements made to recover part of the cost of the project from beneficiaries. (Usually this section will not address recovery of loans; this matter should be discussed in the sections bearing on credit.) Appropriate cross-references may be made to the section on financing (6.5). In most cases,

farmers will be called on to share the cost of the initial investment in on-farm works under the financing plan of the project. The question of cost recovery frequently arises in irrigation projects, in which there may be a problem about the extent to which farmers should bear the cost of operation and maintenance. This may involve questions of government policy about income distribution, or even foodgrain prices, and of financial arrangements in other irrigation projects.

9. Benefits and Justification

This is a crucial part of the project report in which all data discussed in previous parts are brought together and an assessment made—all things considered—about whether to proceed with the project.

9.1 *Social benefit*

A project usually will have benefits beyond those that are simply financial and economic. A general section may be devoted to the effects of the project on food production, import substitution, foreign exchange earnings, and the like. If the project is of interest mainly because of its social benefit, such as its beneficial effect on the incomes of the poorest farmers, this section takes on added importance, and separate sections devoted to one or another significant social aspect may be in order, as noted below. Because these topics will have been discussed in earlier sections, care should be taken to minimize duplication, and only a brief summary may be needed.

9.1.1 INCOME DISTRIBUTION. The extent to which the income of the poorest sector of the rural population is improved as a result of the project may be shown. Reference must be made to the relative improvement in comparison with other groups in the country.

9.1.2 EMPLOYMENT. The extent to which the project reduces underemployment and unemployment may be assessed. This may be quantified in terms of work years created by the project, with distinction made between permanent employment and employment during the investment or construction phase. The number of jobs created might be compared with the expected increase in the labor force of the project area.

9.1.3 ACCESS TO LAND. If the project includes a land settlement or land reform element, the distribution of land rights with and without the project should be demonstrated.

9.1.4 INTERNAL MIGRATION. In countries where rural-urban migration is a serious problem, it may be useful to note the possible effect of the project on rural-urban migration. Quantification will probably prove difficult.

9.1.5 NUTRITION AND HEALTH. If the project is located in an area where serious nutrition or health problems exist, or if the project is directed toward groups with nutrition and health deficiencies, the expected effects of the project on these problems might be mentioned. In some cases, the effect on nutrition may be quantified in the daily intake of calories or protein that is expected as a result of the project.

9.1.6 OTHER INDICATORS OF THE QUALITY OF LIFE. Some projects may have a significant effect on the quality of rural life through improvements in access to domestic water supplies, electricity, schools, and the like. These may be mentioned and the quantities of the new amenities noted.

9.2 *Economic benefit*

Finally, the economic desirability of the project should be assessed. Economic costs and benefits are valued along the lines discussed in chapter 7, aggregated as discussed in chapter 8, and evaluated using one or more of the measures of project worth as discussed in chapter 9. An integral part of this section will be to demonstrate through sensitivity analysis, as discussed in chapter 10, the effects of different assumptions about efficiency and prices on the project's wealth-generating potential.

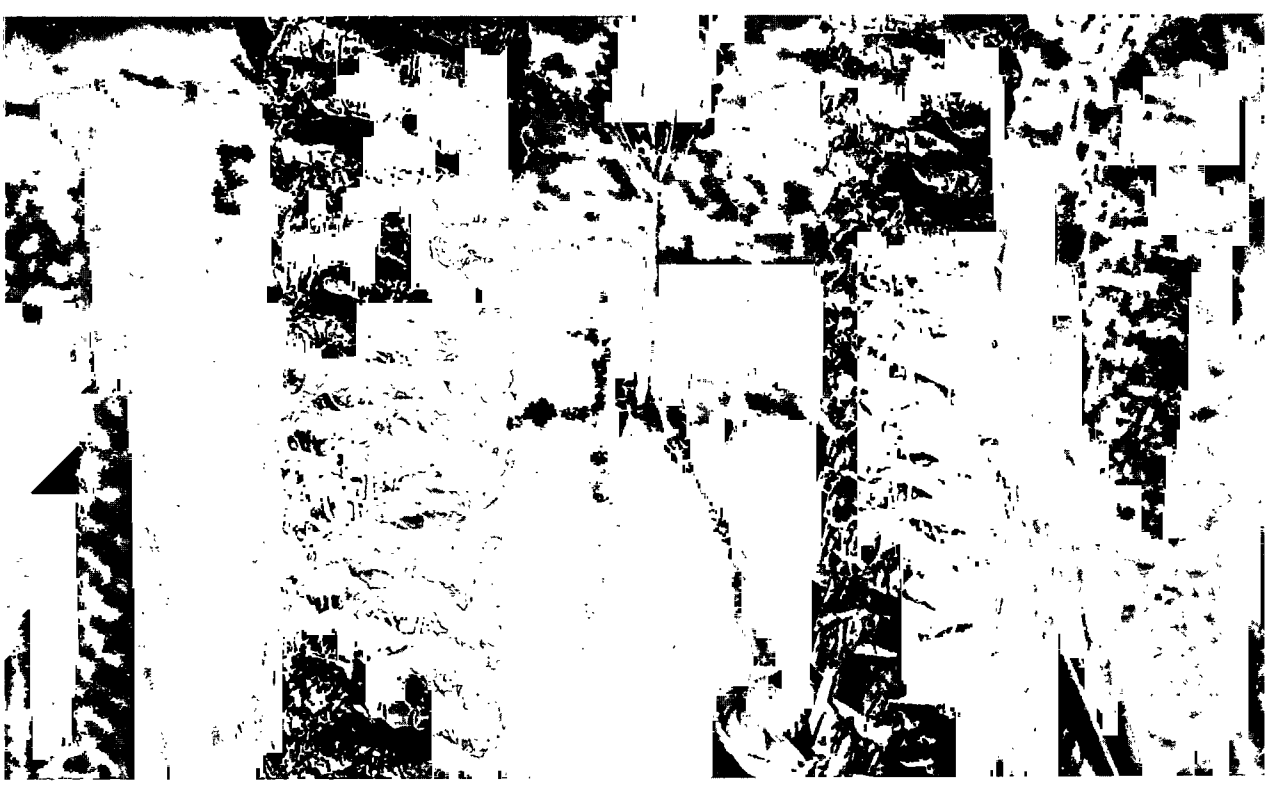
10. Outstanding Issues

Almost every project will have outstanding issues that must be resolved after the preparation report is presented. These considerations may relate to project rationale, policy issues affecting the project, management and other staffing issues, and financing arrangements. The most important of these should be set forth explicitly so that they are drawn forcefully to the attention of readers who must take the necessary actions.

11. Annexes

The annexes to the preparation report contain the detailed support for the project. The main text is written with the general reader in mind, but the annexes will generally be examined in detail primarily by specialists and should be written with the specialist in mind. A large proportion of the annex materials probably will be in the form of tables, maps, drawings, charts, diagrams, and photographs. The annexes will vary widely according to the kind and complexity of the project. They usually are presented in the order in which they are referred to in the main text. Often they are published in a separate volume and reproduced in only the number of copies needed to supply the various specialists and agencies directly concerned with project decisions. Among other topics, annexes may include an amplification of the part on the background of the project

(3); surveys, investigation, laboratory results, and data analyses and interpretations to support the part on the project area (5); studies, designs, estimates, and schedules to support the part on the project (6); detailed proposals to support the part on organization and management (7); farm budgets, projected enterprise accounts, market assessments, and other information to support the part on production, markets, and financial results (8); and analytical material, including shadow prices and assumptions about the foreign exchange premium, to support the part on benefits and justification (9).



Appendix B

Three-decimal Discounting Tables

To CALCULATE most discounted measures of project worth the three-decimal discounting tables reproduced (from Gittinger 1973) at the end of this appendix are sufficient. In general, they will permit estimations to three significant digits for net present worth, to the nearest whole percentage point for internal rate of return, and to a hundredth of a ratio point for benefit-cost and net benefit-investment ratios—as much precision as the underlying data will justify in agricultural projects (see the section on "How Far to Carry Out Computations of Discounted Measures" in chapter 9).

There are instances in which the intervals between percentage points in these tables will not permit computation of the internal rate of return to the nearest percentage point (see the section on "Computing the Internal Rate of Return" in chapter 9). There are also cases in which the opportunity cost of capital to be used for computing net present worth, the benefit-cost ratio, or the net benefit-investment ratio is not given in these tables. In these instances resort will have to be made to more detailed tables, or the factors will have to be calculated directly.

A number of suitable, more detailed discounting tables are available. [Gittinger (1973) contains such a set.] The discount factor, the present worth of an annuity factor, and the capital recovery factor can be calcu-

Facing page: Harvesting dates in Tunisia.

lated on any inexpensive calculator with memory and repeat features, although the computation can become a bit repetitive. The method is discussed in the last section of chapter 10.

When a somewhat more complex calculator with capability to compute powers is available, the standard formulas below may be used to obtain directly the factors most commonly used in project analysis. Each formula assumes an interest rate of i per period and a term of n periods. P is the present worth, or the amount at the present time, t_0. F is the future worth, or the amount in the future at the end of the nth period. A is the annuity, or the level payment, to be made at the end of each of n periods.

Compounding Factor for 1

The factor is:

$$(1 + i)^n.$$

It is used to calculate the future worth (F) of a present amount (P) at the end of the nth period at the interest rate of i. The formula is:

$$F = P(1 + i)^n.$$

Compounding Factor for 1 per annum

The factor is:

$$\frac{(1 + i)^n - 1}{i}.$$

It is used to calculate the future accumulated value (F) at the end of the nth period at the interest rate of i, if a sequence of equal payments (the amount of each payment being A) will be made at the end of each of the n periods. The formula is:

$$F = A \frac{(1 + i)^n - 1}{i}.$$

Sinking Fund Factor

The factor is:

$$\frac{i}{(1 + i)^n - 1}.$$

It is used to calculate the amount of each equal payment (A) to be made at the end of each of n periods to accumulate to a given future worth (F) at the end of the nth period at the interest rate of i. The formula is:

$$A = F \frac{i}{(1 + i)^n - 1}.$$

Note that the sinking fund factor is the reciprocal of the compounding factor for 1 per year.

Discount Factor

The factor is:

$$\frac{1}{(1 + i)^n}.$$

It is used to calculate the present worth (P) of a future value (F) at the end of the nth period at the interest rate of i. The formula is:

$$P = F \frac{1}{(1 + i)^n}.$$

Present Worth of an Annuity Factor

The factor is:

$$\frac{(1 + i)^n - 1}{i(1 + i)^n}.$$

It is used to calculate the present worth (P) of a sequence of level payments (the amount of each payment being A) to be made at the end of each of n periods at the interest rate of i. The formula is:

$$P = A \frac{(1 + i)^n - 1}{i(1 + i)^n}.$$

Capital Recovery Factor

The factor is:

$$\frac{i(1 + i)^n}{(1 + i)^n - 1}.$$

It is used to calculate the amount of each level payment (A) to be made at the end of each of n periods to recover the present amount (P) at the end of the nth period at the interest rate of i. The formula is:

$$A = P \frac{i(1 + i)^n}{(1 + i)^n - 1}.$$

Note that the capital recovery factor is the reciprocal of the present worth of an annuity factor.

COMPOUNDING AND DISCOUNTING TABLES

6. *Three-decimal Table for Discount Factor, Various Rates*

DISCOUNT FACTOR—How much 1 at a future date is worth today.

Year	1%	3%	5%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	24%	25%	26%	28%	30%	35%	40%	45%	50%	Year
1	990	971	952	943	926	909	893	877	870	862	847	833	820	806	800	794	781	769	741	714	690	667	1
2	980	943	907	890	857	826	797	769	756	743	718	694	672	650	640	630	610	592	549	510	476	444	2
3	971	915	864	840	794	751	712	675	658	641	609	579	551	524	512	500	477	455	406	364	328	296	3
4	961	888	823	792	735	683	636	592	572	552	516	482	451	423	410	397	373	350	301	260	226	198	4
5	951	863	784	747	681	621	567	519	497	476	437	402	370	341	328	315	291	269	223	186	156	132	5
6	942	837	746	705	630	564	507	456	432	410	370	335	303	275	262	250	227	207	165	133	108	088	6
7	933	813	711	665	583	513	452	400	376	354	314	279	249	222	210	198	178	159	122	095	074	059	7
8	923	789	677	627	540	467	404	351	327	305	266	233	204	179	168	157	139	123	091	068	051	039	8
9	914	766	645	592	500	424	361	308	284	263	225	194	167	144	134	125	108	094	067	048	035	026	9
10	905	744	614	558	463	386	322	270	247	227	191	162	137	116	107	099	085	073	050	035	024	017	10
11	896	722	585	527	429	350	287	237	215	195	162	135	112	094	086	079	066	056	037	025	017	012	11
12	887	701	557	497	397	319	257	208	187	168	137	112	092	076	069	062	052	043	027	018	012	008	12
13	879	681	530	469	368	290	229	182	163	145	116	093	075	061	055	050	040	033	020	013	008	005	13
14	870	661	505	442	340	263	205	160	141	125	099	078	062	049	044	039	032	025	015	009	006	003	14
15	861	642	481	417	315	239	183	140	123	108	084	065	051	040	035	031	025	020	011	006	004	002	15
16	853	623	458	394	292	218	163	123	107	093	071	054	042	032	028	025	019	015	008	005	003	002	16
17	844	605	436	371	270	198	146	108	093	080	060	045	034	026	023	020	015	012	006	003	002	001	17
18	836	587	416	350	250	180	130	095	081	069	051	038	028	021	018	016	012	009	005	002	001	001	18
19	828	570	396	331	232	164	116	083	070	060	043	031	023	017	014	012	009	007	003	002	001	000	19
20	820	554	377	312	215	149	104	073	061	051	037	026	019	014	012	010	007	005	002	001	001	000	20
21	811	538	359	294	199	135	093	064	053	044	031	022	015	011	009	008	006	004	002	001	000	000	21
22	803	522	342	278	184	123	083	056	046	038	026	018	013	009	007	006	004	003	001	001	000	000	22
23	795	507	326	262	170	112	074	049	040	033	022	015	010	007	006	005	003	002	001	000	000	000	23
24	788	492	310	247	158	102	066	043	035	028	019	013	008	006	005	004	003	002	001	000	000	000	24
25	780	478	295	233	146	092	059	038	030	024	016	010	007	005	004	003	002	001	001	000	000	000	25
26	772	464	281	220	135	084	053	033	026	021	014	009	006	004	003	002	002	001	000	000	000	000	26
27	764	450	268	207	125	076	047	029	023	018	011	007	005	003	002	002	001	001	000	000	000	000	27
28	757	437	255	196	116	069	042	026	020	016	010	006	004	002	002	002	001	001	000	000	000	000	28
29	749	424	243	185	107	063	037	022	017	014	008	005	003	002	002	001	001	000	000	000	000	000	29
30	742	412	231	174	099	057	033	020	015	012	007	004	003	002	001	001	001	000	000	000	000	000	30
35	706	355	181	130	068	036	019	010	008	006	003	002	001	001	000	000	000	000	000	000	000	000	35
40	672	307	142	097	046	022	011	005	004	003	001	001	000	000	000	000	000	000	000	000	000	000	40
45	639	264	111	073	031	014	006	003	002	001	001	000	000	000	000	000	000	000	000	000	000	000	45
50	608	228	087	054	021	009	003	001	001	001	000	000	000	000	000	000	000	000	000	000	000	000	50

Source: Gittinger (1973, pp. 102–03).

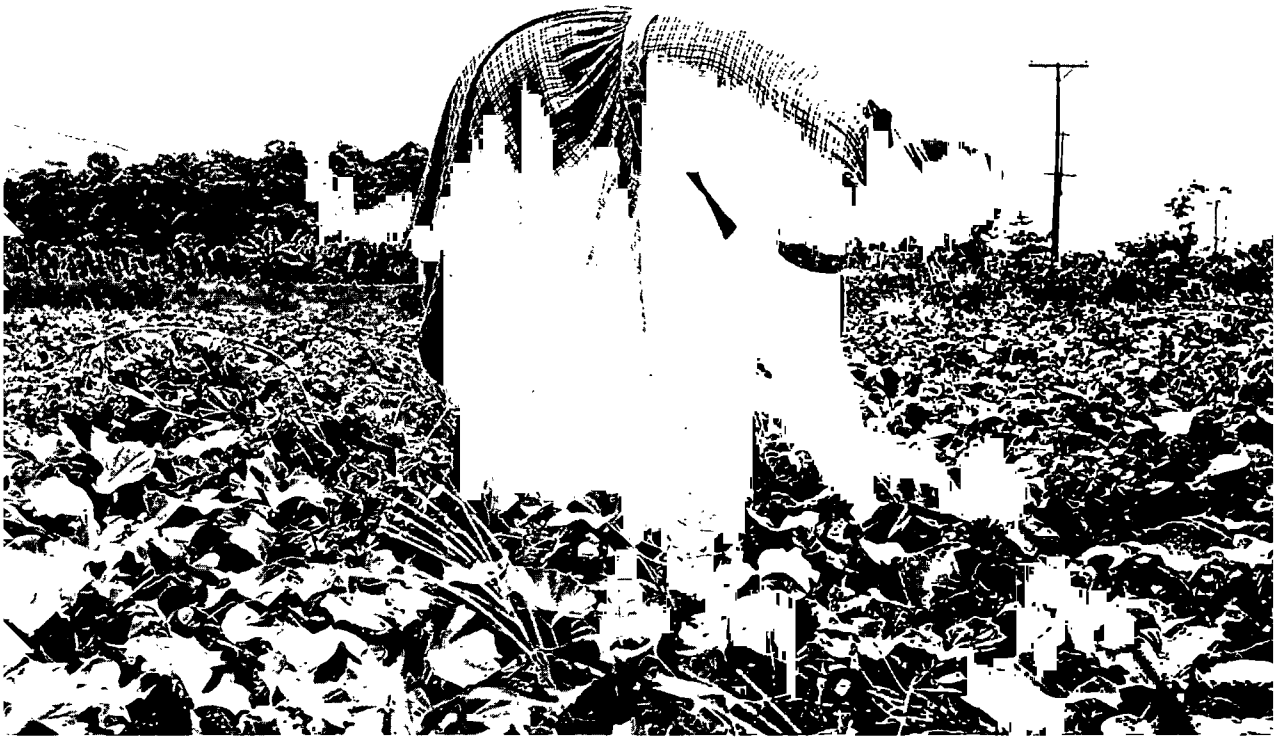
COMPOUNDING AND DISCOUNTING TABLES

7. *Three-decimal Table for Present Worth of an Annuity Factor, Various Rates*

PRESENT WORTH OF AN ANNUITY FACTOR—
How much 1 received or paid annually for X years is worth today.

Year	1%	3%	5%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	24%	25%	26%	28%	30%	35%	40%	45%	50%	Year
1	990	971	952	943	926	909	893	877	870	862	847	833	820	806	800	794	781	769	741	714	690	667	1
2	1 970	1 913	1 859	1 833	1 783	1 736	1 690	1 647	1 626	1 605	1 566	1 528	1 492	1 457	1 440	1 424	1 392	1 361	1 289	1 224	1 165	1 111	2
3	2 941	2 829	2 723	2 673	2 577	2 487	2 402	2 322	2 283	2 246	2 174	2 106	2 042	1 981	1 952	1 923	1 868	1 816	1 696	1 589	1 493	1 407	3
4	3 902	3 717	3 546	3 465	3 312	3 170	3 037	2 914	2 855	2 798	2 690	2 589	2 494	2 404	2 362	2 320	2 241	2 166	1 997	1 849	1 720	1 605	4
5	4 853	4 580	4 329	4 212	3 993	3 791	3 605	3 433	3 352	3 274	3 127	2 991	2 864	2 745	2 689	2 635	2 532	2 436	2 220	2 035	1 876	1 737	5
6	5 795	5 417	5 076	4 917	4 623	4 355	4 111	3 889	3 784	3 685	3 498	3 326	3 167	3 020	2 951	2 885	2 759	2 643	2 385	2 168	1 983	1 824	6
7	6 728	6 230	5 786	5 582	5 206	4 868	4 564	4 288	4 160	4 039	3 812	3 605	3 416	3 242	3 161	3 083	2 937	2 802	2 508	2 263	2 057	1 883	7
8	7 652	7 020	6 463	6 210	5 747	5 335	4 968	4 639	4 487	4 344	4 078	3 837	3 619	3 421	3 329	3 241	3 076	2 925	2 598	2 331	2 108	1 922	8
9	8 566	7 786	7 108	6 802	6 247	5 759	5 328	4 946	4 772	4 607	4 303	4 031	3 786	3 566	3 463	3 366	3 184	3 019	2 665	2 379	2 144	1 948	9
10	9 471	8 530	7 722	7 360	6 710	6 145	5 650	5 216	5 019	4 833	4 494	4 192	3.923	3 682	3.571	3 465	3 269	3 092	2 715	2 414	2 168	1 965	10
11	10 368	9 253	8 306	7 887	7 139	6 495	5 938	5 453	5 234	5 029	4 656	4 327	4 035	3 776	3 656	3 543	3 335	3 147	2 752	2 438	2 185	1 977	11
12	11 255	9 954	8 863	8 384	7 536	6 814	6 194	5 660	5 421	5 197	4 793	4 439	4 127	3 851	3 725	3 606	3 387	3 190	2 779	2 456	2 196	1 985	12
13	12 134	10 635	9 394	8 853	7 904	7 103	6 424	5 842	5 583	5 342	4 910	4 533	4 203	3 912	3.780	3 656	3 427	3 223	2 799	2 469	2 204	1 990	13
14	13 004	11 296	9 899	9 295	8 244	7 367	6 628	6 002	5 724	5 468	5 008	4 611	4 265	3 962	3 824	3 695	3 459	3 249	2 814	2 478	2 210	1 993	14
15	13 865	11 938	10 380	9 712	8 559	7 606	6 811	6 142	5 847	5 575	5 092	4 675	4 315	4 001	3 859	3 726	3 483	3 268	2 825	2 484	2 214	1 995	15
16	14 718	12 561	10 838	10 106	8 851	7 824	6 974	6 265	5 954	5 668	5 162	4 730	4 357	4 033	3 887	3 751	3 503	3 283	2 834	2 489	2 216	1 997	16
17	15 562	13 166	11 274	10 477	9 122	8 022	7 120	6 373	6 047	5 749	5 222	4 775	4 391	4 059	3 910	3 771	3 518	3 295	2 840	2 492	2 218	1 998	17
18	16 398	13 754	11 690	10 828	9 372	8 201	7 250	6 467	6 128	5 818	5 273	4 812	4 419	4 080	3 928	3 786	3 529	3 304	2 844	2 494	2 219	1 999	18
19	17 226	14 324	12 085	11 158	9 604	8 365	7 366	6 550	6 198	5 877	5 316	4 843	4 442	4 097	3 942	3 799	3 539	3 311	2 848	2 496	2 220	1 999	19
20	18 046	14 877	12 462	11 470	9 818	8 514	7 469	6 623	6 259	5 929	5 353	4 870	4 460	4 110	3 954	3 808	3 546	3 316	2 850	2 497	2 221	1 999	20
21	18 857	15 415	12 821	11 764	10 017	8 649	7 562	6 687	6 312	5 973	5 384	4 891	4 476	4 121	3 963	3 816	3 551	3 320	2 852	2 498	2 221	2 000	21
22	19 660	15 937	13 163	12 042	10 201	8 772	7 645	6 743	6 359	6 011	5 410	4 909	4 488	4 130	3 970	3 822	3 556	3 323	2 853	2 498	2 222	2 000	22
23	20 456	16 444	13 489	12 303	10 371	8 883	7 718	6 792	6 399	6 044	5 432	4 925	4 499	4 137	3 976	3 827	3 559	3 325	2 854	2 499	2 222	2 000	23
24	21 243	16 936	13 799	12 550	10 529	8 985	7 784	6 835	6 434	6 073	5 451	4 937	4 507	4 143	3 981	3 831	3 562	3 327	2 855	2 499	2 222	2 000	24
25	22 023	17 413	14 094	12 783	10 675	9 077	7 843	6 873	6 464	6 097	5 467	4 948	4 514	4 147	3 985	3 834	3 564	3 329	2 856	2 499	2 222	2 000	25
26	22 795	17 877	14 375	13 003	10 810	9 161	7 896	6 906	6 491	6 118	5 480	4 956	4 520	4 151	3 988	3 837	3 566	3 330	2 856	2 500	2 222	2 000	26
27	23 560	18 327	14 643	13 211	10 935	9 237	7 943	6 935	6 514	6 136	5 492	4 964	4 524	4 154	3 990	3 839	3 567	3 331	2 856	2 500	2 222	2 000	27
28	24 316	18 764	14 898	13 406	11 051	9 307	7 984	6 961	6 534	6 152	5 502	4 970	4 528	4 157	3 992	3 840	3 568	3 331	2 857	2 500	2 222	2 000	28
29	25 066	19 188	15 141	13 591	11 158	9 370	8 022	6 983	6 551	6 166	5 510	4 975	4 531	4 159	3 994	3 841	3 569	3 332	2 857	2 500	2 222	2 000	29
30	25 808	19 600	15 372	13 765	11 258	9 427	8 055	7 003	6 566	6 177	5 517	4 979	4 534	4 160	3 995	3 842	3 569	3 332	2 857	2 500	2 222	2 000	30
35	29 409	21 487	16 374	14 498	11 655	9 644	8 176	7 070	6 617	6 215	5 539	4 992	4 541	4 164	3 998	3 845	3 571	3 333	2 857	2 500	2 222	2 000	35
40	32 835	23 115	17 159	15 046	11 925	9 779	8 244	7 105	6 642	6 233	5 548	4 997	4 544	4 166	3 999	3 846	3 571	3 333	2 857	2 500	2 222	2 000	40
45	36 095	24 519	17 774	15 456	12 108	9 863	8 283	7 123	6 654	6 242	5 552	4 999	4 545	4 166	4 000	3 846	3 571	3 333	2 857	2 500	2 222	2 000	45
50	39 196	25 730	18 256	15 762	12 233	9 915	8 304	7 133	6 661	6 246	5 554	4 999	4 545	4 167	4 000	3 846	3 571	3 333	2 857	2 500	2 222	2 000	50

Source: Gittinger (1973, pp. 104–05).



Appendix C

Sources of Institutional Assistance for Project Preparation

FOR SPECIALIZED ASSISTANCE in preparing complex agricultural projects, many governments may wish to turn to one of the bilateral or multilateral international aid agencies or to engage the services of commercial consultants.

Bilateral Assistance

Some governments may have a special interest in assisting developing countries to prepare particular projects. Information about bilateral assistance of this kind may be obtained from the embassy or equivalent office of the prospective donor country.

Multilateral Assistance

In addition to assistance agreed on by two governments, a government can enter into arrangements for assistance in preparing projects with a variety of international agencies.

Facing page: Cultivating sweet potatoes in Jamaica.

European Community

The European Community through the European Development Fund provides financial aid and technical assistance to sixty-one developing countries that are signatories to the Lome Convention and to some twenty-seven other countries with which it has special agreements. It is the task of the recipient country to prepare projects intended for assistance from the Community, but Community funds may be used to finance studies of, or technical assistance for, project preparation. More information about assistance for preparing projects may be obtained from the European Community delegation in Lome Convention countries and in seven North African and Middle Eastern countries, or from the Directorate General for Development of the Commission of the European Communities in Brussels. The Commission has prepared two documents intended as guides, *Appraisal of Productive Projects in Agriculture: Economic Analysis and Rate of Return* (1980*a*) and the *Manual for Preparing and Appraising Project Dossiers* (1980*b*).

United Nations Development Programme

Within the United Nations system, the principal source of technical assistance, including help for project preparation, is the United Nations Development Programme (UNDP). The UNDP finances preinvestment activities, including surveys of physical resources and of better ways to use them; analyses of national economic sectors, including agriculture, as a basis for formulating coordinated investment programs or for defining priorities; feasibility studies of investment projects; applied research; manpower training; technical education; and the like.

As a rule, the UNDP does not itself carry out the preinvestment activities it finances. Instead, it turns to executing agencies—the United Nations Office of Technical Cooperation, the specialized agencies of the United Nations, the World Bank, regional development banks, and occasionally other institutions. In agriculture, the Food and Agriculture Organization (FAO) normally has been the executing agency. The World Bank has on occasion taken this responsibility, generally in such cases as credit projects for which the World Bank has special experience to offer.

Each developing country that wishes to take advantage of UNDP assistance works out an agreed "Country Programme" that identifies the sectors or activities for which assistance will be used and estimates the amounts needed. This program can be modified by the country in consultation with the UNDP as new information becomes available about the feasibility, priority, content, timing, and required resources for each activity. Most activities undertaken with UNDP assistance require government contributions, either in kind or in local currency.

Once it is agreed that assistance for preparing a particular project will be included in the country program, a tripartite agreement is drawn up between the country receiving assistance, the UNDP, and the executing

agency. This specifies the arrangements for carrying out the activity, details of the reports to be prepared, provision for suspension and termination, and details of the financial contributions provided by the UNDP and the government concerned.

More information about assistance for preparing particular projects may be obtained from the UNDP resident representative stationed in most developing countries. The representative can also make available copies of many UNDP preinvestment and feasibility studies that provide examples for those considering similar activities.

Food and Agriculture Organization–development bank cooperative programs

The FAO has established an Investment Centre staffed by a team of multidisciplinary experts who specialize in the formulation of investment projects. The center helps to identify and prepare agricultural projects in close cooperation with the World Bank, the Inter-American Development Bank, the Asian Development Bank, the African Development Bank, the International Fund for Agricultural Development, and several Arab funds. It also has cooperative programs with national banks and financing institutions in developing countries under the FAO/Bankers Programme.

The Investment Centre is especially useful for bringing to bear a comparative knowledge of similar projects in different countries under roughly comparable conditions and for its familiarity with the special requirements of lending institutions. Usually the Investment Centre helps with project identification and preparation in two distinct stages. The first is a preliminary view of the possible project to gain an idea immediately of what activities should or should not be included, to assess the information that is available or would have to be obtained to prepare a sound analysis, to gain an idea of the administrative and organizational problems, and to be sure a project has appropriate priority within the overall development program of the country. An identification mission generally remains in the country about three weeks. If a government then wishes further assistance, the Centre may provide specialists to help with project preparation. At this stage the technicians assist in preparing detailed critical analyses of the technical, financial, and economic data and assumptions. The Centre's specialists help marshall the available data for the financial and economic analysis and for preparing the project for presentation to the financing agency. The time needed for project preparation, of course, is dependent upon the complexity of the project, and the Centre may send several missions to a country in connection with the project preparation, particularly if there are serious data gaps.

The simplest way for a country to obtain assistance under these FAO-bank cooperative programs is to make direct application to the FAO or to the appropriate bank. This may be done either formally to the Director

General of the FAO through the FAO representative in the country, or informally to the director of the FAO Investment Centre directly or through an FAO or bank staff member. The application may be made by letter or by personal contact at convenient opportunities such as the visit of a staff member of the appropriate agency to the country, bank annual meetings, FAO conferences, and the like. There is no fixed timetable for considering and approving applications for assistance, although in the nature of the activity there is generally a considerable lag between the first letter or conversation and the time the project is actually ready for work to begin. It is therefore important to make contacts early and to provide as much background information as possible on the project proposed.

In the case of FAO-bank cooperative programs, the major portion of the cost is usually borne by the international agencies, but in some instances the government involved may be asked to provide local transport and similar services.

World Bank

Under certain circumstances, World Bank assistance may be available to help with project identification and preparation.

World Bank economic missions, sector survey missions, operational missions, and resident missions may bring to a government's attention projects that seem to offer prospects for good returns. Project supervision missions by Bank staff members in the course of work on particular projects may identify later stages of ongoing projects or similar projects for possible investment.

Once potential projects have been identified, the World Bank in some instances is able to assist in preparation. (World Bank assistance of any form in preparing a project does not, however, constitute a commitment of Bank financing for the resulting project.) The Bank may advise on the planning of feasibility studies—specifying the information that has to be gathered (often by providing questionnaires), defining the studies needed to obtain this information, establishing the relative priority and emphasis to be given to different aspects of the studies, and advising about how these studies can best be organized and presented and, when appropriate, financed. In the later stages of preparation, the Bank may also help ensure that the feasibility study is progressing along the right lines and that it will cover the necessary aspects. This assistance may range from occasional visits by Bank staff to the formal participation of Bank staff in steering committees.

Sometimes the World Bank also finances project preparation studies undertaken either by government agencies or by commercial consultants. World Bank financing for a project may include funds for preparing subsequent phases or additional related projects. In a few cases when a large number of potential projects needed study and preparatory work, a separate loan for technical assistance has been extended.

Member countries of the World Bank can occasionally make use of the World Bank's Project Preparation Facility to finance preparation of projects expected to be presented for Bank financing. This assistance is only extended when other alternatives for financing the preparation either are not available or require excessive administrative effort. Funds advanced under this arrangement are repaid from loan or grant proceeds if a loan or grant is made or over a five-year period if the project is not financed by the World Bank. The facility is usually available only to poor countries that could not reasonably be expected to finance the activities from their own resources pending reimbursement out of an eventual loan or grant. The funds may be used to provide additional support for the group responsible for preparing the project or to finance gaps in the project preparation that must be filled before the project can be appraised by the Bank. Examples of the kinds of omission that these funds could be used to rectify include inadequate economic analysis, incomplete market studies, omission of a monitoring system, the need for more complete information about land tenure in the project area, or unforeseen environmental implications of the project that require further study.

Consultants

Many governments will want to engage either individual consultants or consulting firms to assist with project preparation. Sometimes assistance will be sought for only a particular aspect of project preparation, other times for the entire preparation. The United Nations Industrial Development Organization (UNIDO) has prepared an extremely useful *Manual on the Use of Consultants in Developing Countries* (1972*b*). This contains many helpful suggestions about how to select, engage, and use consultants, especially consulting firms. The World Bank (1981*c*) has prepared a pamphlet that outlines its own approach to the use of consultants and the use of consultants by governments in connection with Bank-financed projects, as has the Inter-American Development Bank (1981).

There are many reasons why governments may wish to turn to consultants. Many government agencies are already fully occupied and simply do not have the time to devote to proper project preparation. External help can be brought in that can devote its full attention to preparing the project within a specified time. Required skills or specialized know-how may not be available in the country. A problem may arise that calls for the attention of specialists, but it is not expected to repeat itself—hence, it is not worth developing local expertise in the area. Even when the overall project preparation is to be carried out by a government agency, there may be special technical assessments for which outside expertise is desirable—an analysis of soils for an irrigation project, a market analysis for a specialty crop grown for export, or chemical tests on tree species that might be planted for pulpwood. Consultants may be able to use a

new or more up-to-date approach in solving problems. They may also be used to provide an outside, impartial view or may be asked for an independent second opinion.

Consultants may be sought from a variety of sources. Many times an individual or a particular firm will have done similar work previously, and a government may wish to engage the services again. Local consultants or consulting firms may already be well known. Individual consultants may come from local universities. The UNIDO *Manual on the Use of Consultants* has a list of professional consulting associations that will make suggestions about possible consultants. Embassies often have lists available of consultants in their countries. The World Bank maintains lists of individuals and firms that have expressed an interest in consulting, but does not keep a list of "approved" consultants. The Bank's general files on consulting firms are available to visiting representatives from Bank borrowers or member governments who need to review and assess the experience and qualifications of consulting firms they are considering for projects.

An increasing number of national consulting firms of suitable competence exist in developing countries. More might grow if more governments were to adopt a conscious policy to encourage them and to assure them an opportunity to compete for suitable work. When national consulting firms are used instead of government agencies, the advantages of having a group of people who can focus on project preparation without the pressures of day-to-day routine administration are realized. At the same time, the specialized skills that such consultants gain in the course of their work remain in the country and can be available again in the future. In cases where a national consulting firm does not have the full range of expertise needed to prepare a project, the national firm can often draw upon a foreign associate for particular specialized skills and use its own resources for less esoteric work. Such links between local and foreign firms are increasingly common in the consulting field. Retaining overall control in local hands means that local conditions can be fully considered while foreign expertise is utilized. Sometimes, however, national firms simply will not have enough of the skills needed to prepare certain kinds of projects, and a government will have to turn to an international consulting firm. When this happens, the terms of reference for the foreign consultant may provide for an association with a local firm and include a planned training program. Through their association with the foreign consulting firm, the national consultants can increase their expertise. Then, as similar projects are prepared in the future, the involvement of the foreign firm can decrease until the national firm is able to undertake these kinds of consulting assignments entirely on its own.

A frequent concern about the use of consultants is the cost. Often the fees of consultants, especially those from abroad, seem very high compared with government salary scales in the country. One way to reduce the cost of consulting services may be to rely more on qualified local consultants. In the final analysis, however, if an individual consultant or

a consulting firm can prepare a sizable project well, even what seems a rather high consulting fee may not be unreasonable. Of course, care must be taken to ensure that any consulting fees asked are reasonable given the complexity of the project and the amounts charged for similar work in other instances. Nonetheless, as the UNIDO *Manual on the Use of Consultants* states, "a good job is well worth the cost, and a poor one is a loss, regardless of price" (1972*b*, p. 19). The cost of consulting services to prepare an agricultural project seldom amounts to more than 5 to 10 percent of the project cost. As the UNIDO *Manual* notes, a saving of, say, 10 percent on consulting fees means no more than a saving of 1 percent on the project cost. But poor consulting services and bad engineering can lead to very substantial cost overruns (1972*b*, ibid.).

Bibliography

Adler, Hans A. 1971. *Economic Appraisal of Transport Projects: A Manual with Case Studies.* Bloomington: Indiana University Press.

An introductory manual focusing on transport projects that include rural roads. Includes case examples.

Austin, James E. 1981. *Agroindustrial Project Analysis.* Baltimore, Md.: Johns Hopkins University Press.

A very useful discussion of the elements of formulating projects for industries that use agricultural raw materials. The emphasis is more on the project design than on narrow methodological considerations.

Bacha, Edmar, and Lance Taylor. 1972. "Foreign Exchange Shadow Prices: A Critical Review of Current Theories." In *Benefit Cost Analysis 1971,* edited by Arnold C. Harberger and others, pp. 29–59. Chicago: Aldine-Atherton.

A comprehensive, formal review of the theory of foreign exchange shadow prices.

Bannock, G., R. E. Baxter, and R. Rees. 1972. *The Penguin Dictionary of Economics.* Harmondsworth, U.K.: Penguin Books.

A standard reference for economic terms.

Barnum, Howard N., and Lyn Squire. 1979. *A Model of an Agricultural Household: Theory and Evidence.* Baltimore, Md.: Johns Hopkins University Press.

Facing page: Carrying rice straw from the field in Bangladesh.

Discusses in considerable detail the economics of rural labor supply in a developing country.

Baum, Warren C. 1978. "The Project Cycle." *Finance and Development*, vol. 15, no. 4 (December), pp. 10–17. Also available in pamphlet form (1982) from the World Bank.

An updated version of an earlier article that established "project cycle" as a concept in development economics.

Benjamin, McDonald P. 1981. *The Making of an Agricultural Project: Principles and Case Studies.* London: Longman.

Traces the process of identifying and preparing an agricultural project.

Bergmann, Hellmuth, and Jean-Marc Boussard. 1976. *Guide to the Economic Evaluation of Irrigation Projects.* Rev. version. Paris: Organisation for Economic Co-operation and Development (OECD).

Focusing entirely on irrigation projects, this work devotes considerable attention to the data needed for project evaluation. The analytical method advanced is somewhat different from, but is not incompatible with, that outlined in this book. An interesting set of blank tables for presenting the results of the analysis is included. Well worthwhile for those working on irrigation investments.

Bierman, Harold, Jr., and Seymour Smidt. 1980. *The Capital Budgeting Decision.* 5th ed. New York: Macmillan.

Good introductory text on investment analysis; intended more for engineering and industrial than for agricultural applications.

Bigg, W. W., and R. E. G. Perrins. 1971. *Spicer and Pegler's Bookkeeping and Accounting.* 17th rev. ed. London: English Language Book Society and H.F.L. (Publishers) Ltd.

A standard, university-level introductory text on accounting.

Brown, David W., William F. Litwiller, and Frank Fender. 1974. *Manual for Agricultural Capital Project Analysis.* Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Traces the steps in formulating and presenting an agricultural project. Complementary to this book.

Brown, Maxwell L. 1979. *Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis.* Baltimore, Md.: Johns Hopkins University Press.

A basic text discussing in detail preparation of farm budgets for use in agricultural project analyses, including concepts of farm income, partial budgets, farm models, livestock projections, and aggregation.

Bruce, Colin M. F. 1976. *Social Cost-Benefit Analysis: A Guide for Country and Project Economists to the Derivation and Application of Economic and Social Accounting Prices.* World Bank Staff Working Paper no. 239. Washington, D.C.

Explains the derivation of national parameters used to estimate distributional accounting following the methodology of Squire and van der Tak (1975). It contains a very useful set of worksheets and illustrates their application in Thailand.

———. 1980. "The Stages of Project Planning—An Introduction to Project Planning." CN-301. Washington, D.C.: Economic Development Institute (EDI), World Bank.

Introduces the reader to the concepts and purposes of the various stages of project planning through analysis of the nature of planning; discusses the significance and importance of the various stages; and stresses the need for an acceptance of a project planning system with the political, institutional, and methodological components that make for an effective system.

Bruno, Michael. 1967. "The Optimal Selection of Export-Promoting and Import-Substituting Projects." In *Planning the External Sector: Techniques, Problems, and Policies.* Report on the First Interregional Seminar on Development Planning, Ankara, Turkey, 6–17 September 1965, pp. 88–135. ST/TAO/SER.c/91. New York: United Nations.

A thorough summary of the theoretical and practical problems associated with computing domestic resource cost.

Carnemark, Curt, Jaime Biderman, and David Bovet. 1976. *The Economic Analysis of Rural Road Projects.* World Bank Staff Working Paper no. 421. Washington, D.C.

A discussion of the analytical procedures to apply to rural roads that have low levels of traffic. Emphasizes the interdependence of transport and agricultural production systems in the rural environment and suggests that the analysis should focus on the mechanisms by which transport cost savings are translated into increasing agricultural production and income.

Carruthers, Ian, and Colin Clark. 1981. *The Economics of Irrigation.* Liverpool: Liverpool University Press.

Focuses on irrigation; includes much material dealing with the technical, institutional-organizational-managerial, financial, and economic aspects of irrigation projects.

Commission of the European Communities. 1980*a*. *Appraisal of Productive Projects in Agriculture: Economic Analysis and Rate of Return.* VIII/701/76 Rev. 4. Brussels.

Brief discussion of financial and economic analysis, with particular attention given to the "basic principles to be followed in the economic and financial analysis of the agricultural projects submitted to the Commission for financing." Includes a case study intended as a guide for preparing projects.

———. 1980*b*. *Manual for Preparing and Appraising Project Dossiers.* VIII/527/79-EN. Brussels.

Outlines are given for projects dealing with general agriculture, livestock, rural roads, rural industries, rural health, rural education, sites and services, slaughterhouses, drinking water supply, and drainage.

Delp, Peter, and others. 1977. "Systems Tools for Project Planning." Bloomington: Indiana University, International Development Institute, Program of Advanced Studies in Institution Building and Technical Assistance Methodology.

Discusses a range of tools for planning and analyzing projects, including many tools suitable for use when quantification is difficult.

Eckstein, Otto. 1958. *Water Resource Development: The Economics of Project Evaluation.* Cambridge, Mass.: Harvard University Press.

A theoretical discussion of the issues and problems of project analysis. Classic in its field, but stiff going (written for professional economists).

Espadas, Orlando T. 1977. "Herd Projection Using Hewlett-Packard 67 Calculator." CN-31. Washington, D.C.: Economic Development Institute, World Bank.

Contains the program and detailed instructions about how to use a programmable calculator for herd projections.

Estes, Ralph. 1981. *Dictionary of Accounting.* Cambridge, Mass.: MIT Press.

Convenient, up-to-date reference on accounting terms helpful for those doing financial analysis of projects.

Food and Agriculture Organization (FAO), FAO/World Bank Cooperative Programme. 1975. *Guidelines for the Preparation of Feasibility Studies: Rural Development Projects.* Rome.

See next reference for comment.

———, Investment Centre. 1977. *Guidelines for the Preparation of Agricultural Investment Projects.* Rome.

Two of a series of guidelines for various kinds of agricultural projects prepared by the FAO Investment Centre.

Gittinger, J. Price, ed. 1973. *Compounding and Discounting Tables for Project Evaluation.* Baltimore, Md.: Johns Hopkins University Press.

Basic financial tables prepared with the needs of projects analysts in mind. Includes six-decimal tables for 1 percent through 50 percent by whole percentage points for compounding factor for 1, compounding factor for 1 per annum, sinking fund factor, discount factor, present worth of an annuity factor, and capital recovery factor; summary present worth tables; narrow-interval compounding tables for compounding factor for 1 by intervals of tenths of 1 percent from 0.0 percent through 10.9 percent; and a discussion with examples of how to use the tables.

Gittinger, J. Price, Prem C. Garg, and Alfred Thieme. 1982. "Current Use of Project Analysis Tools in the World Bank and the Inter-American Development Bank." CN-86. Washington, D.C.: Economic Development Institute, World Bank.

A review of the application of project analysis tools in projects financed by the World Bank and the Inter-American Development Bank (IDB) during 1981.

Grant, Eugene L., and W. Grant Ireson. 1964 (4th ed.) and 1970 (5th ed.). *Principles of Engineering Economy.* New York: Ronald.

A standard, thorough text in the field that discusses many questions of application.

Greenwald, Douglas, ed. 1982. *Encyclopedia of Economics.* New York: McGraw-Hill.

Extensive list of economics terms with substantial discussion and references.

Gregerson, Hans M., and Arnoldo H. Contreras. 1979. *Economic Analysis of Forestry Projects.* FAO Forestry Paper no. 17. Rome: Food and Agriculture Organization.

Discusses many of the same concepts dealt with in this book, but with forestry examples. Limited to economic analysis only.

Hansen, John R. 1978. *Guide to Practical Project Appraisal: Social Benefit-Cost Analysis in Developing Counties.* Project Formulation and Evaluation Series no. 3. Sales no. E.78.II.B.3. New York: United Nations.

Provides an excellent introduction to the United Nations Industrial Development Organization (UNIDO) *Guidelines for Project Evaluation* (1972*a*). Especially useful for noneconomists.

Hardie, J. D. M. 1976. *A Guide to Basic Agricultural Project Appraisal in Developing Countries.* Miscellaneous Publication no. 12. Aberdeen, U.K.: University of Aberdeen, School of Agriculture.

An introductory text written to meet the needs of junior staff in developing countries.

Harsh, Stephen B., Larry J. Connor, and Gerald D. Schwab. 1981. *Managing the Farm Business.* Englewood Cliffs, N.J.: Prentice-Hall.

A contemporary farm management text.

Helmers, F. Leslie C. H. 1979. *Project Planning and Income Distribution.* Boston: Martinus Nijhoff.

Excellent review and critique of project analysis theory and practice. Presented in language of formal economics.

Inter-American Development Bank (IDB). 1978. "Guidelines for the Preparation of Loan Applications." Washington, D.C.

Comprehensive and detailed outlines for agricultural projects including rural credit, forestry, integrated rural development, research and extension, agro-industry, livestock development, marketing of agricultural products, and irrigation. At present, most outlines are available in Spanish only.

———. 1981. *Use of Consulting Firms by the IDB and Its Borrowers.* Washington, D.C.

Describes the selection and supervision process, policies, and procedures relating to use of services of consulting firms and individual consultants by the Inter-American Development Bank and its borrowers.

Irvin, George. 1978. *Modern Cost-Benefit Methods. An Introduction to Financial, Economic, and Social Appraisal of Development Projects.* London: Macmillan.

Excellent university-level, introductory text that focuses on methodological issues. Discusses measures of project worth and economic valuation in detail and compares proposed systems of distribution weights.

James, L. D., and R. R. Lee. 1970. *Economics of Water Resources Planning.* New York: McGraw-Hill.

Includes a detailed discussion of the separable costs–remaining benefits method of joint cost allocation.

Kalbermatten, John M., DeAnne S. Julius, and Charles G. Gunnerson. 1982. *Appropriate Sanitation Alternatives: A Technical and Economic Appraisal.* Baltimore, Md.: Johns Hopkins University Press.

Chapter 3 contains a discussion of cost-effectiveness analysis.

Kay, Ronald D. 1981. *Farm Management: Planning, Control, and Implementation.* New York: McGraw-Hill.

A contemporary farm management text with emphasis on the management process.

King, John A., Jr. 1967. *Economic Development Projects and Their Appraisal.* Baltimore, Md.: Johns Hopkins University Press.

An early, descriptive presentation of World Bank projects.

Krishna, Raj. 1967. "Agricultural Price Policy and Economic Development." In *Agricultural Development and Economic Growth*, edited by Herman M. Southworth and Bruce F. Johnston, pp. 497–540. Ithaca, N.Y.: Cornell University Press.

A standard summary of research showing that farmers in developing countries are price responsive. Although data are now dated, the conclusions remain valid and the evidence is among the most clearly laid out available.

Kulp, Earl M. 1977. "Designing and Managing Basic Agricultural Programs." Bloomington: Indiana University, International Development Institute, Program of Advanced Studies in Institution Building and Technical Assistance Methodology.

Presents in detail a system for planning and preparing agricultural projects.

Kutcher, Gary P., and Pasquale L. Scandizzo. 1981. *The Agricultural Economy of Northeast Brazil.* Baltimore, Md.: Johns Hopkins University Press.

An example of a programming model applied to agricultural sector planning.

Lee, James A., coordinating author. 1982. *The Environment, Public Health, and Human Ecology: Considerations for Economic Development.* Washington, D.C.: World Bank.

Discusses the identification and measurement of the effects agricultural and other development projects can have on the environment and human health; includes suggestions about how to avoid or mitigate the undesirable effects through appropriate project design and preparation.

Lieftinck, Pieter, A. Robert Sadove, and Thomas C. Creyke. 1968. *Water and Power Resources of West Pakistan.* 3 vols. Baltimore, Md.: Johns Hopkins University Press.

An example of a programming model applied to agricultural sector planning.

Little, I. M. D., and J. A. Mirrlees. 1974. *Project Appraisal and Planning for Developing Countries.* New York: Basic Books.

Extremely influential book on project analysis that presents many seminal ideas. Written for the professional economist.

Loughlin, James C. 1977. "The Efficiency and Equity of Cost Allocation Methods for Multipurpose Water Projects." *Water Resources Research,* vol. 13, no. 1 (February), pp. 8–14.

Proposed modifications of the separable cost–remaining benefits method of joint cost allocation to increase equity through weighting for the relative amounts of the separable costs assigned to each purpose.

McDiarmid, Orville John. 1977. *Unskilled Labor for Development: Its Economic Cost.* Baltimore, Md.: Johns Hopkins University Press.

Discusses in detail concepts of the economic value of labor and applies these concepts to the economies in East and Southeast Asia.

McKean, Ronald N. 1958. *Efficiency in Government through Systems Analysis with Emphasis on Water Resources Development.* New York: Wiley.

A classic in the field that clearly sets forth the issues. Recommends use of internal rate of return rather than benefit-cost ratio.

Mears, Leon A. 1969. *Economic Project Evaluation with Philippine Cases.* 2 vols. Quezon City: University of the Philippines Press.

A basic text, with cases written for teaching in the Philippines—hence, quite applicable in many South and Southeast Asian nations.

Merrett, A. J., and Allen Sykes. 1963. *The Finance and Analysis of Capital Projects.* London: Longman.

Excellent and thorough text on techniques of project analysis, with emphasis on application for private firms. Particularly good for questions of methodology.

Meyn, Klaus, J. Price Gittinger, and Walter Schaefer-Kehnert. 1980. "Herd Projection Exercise. Paraguay: Livestock and Agricultural Development Project." AE-1124-P. Washington, D.C.: Economic Development Institute, World Bank.

A paper recommending a standardized approach to preparation of herd projections; illustrated by the example from the Paraguay Livestock and Agricultural Project used in chapter 4 of this book.

Mishan, E. J. 1971. "The Postwar Literature on Externalities." *Journal of Economic Literature*, vol. 9, no. 1 (March), pp. 1–28.

A highly technical summary of the literature on secondary effects; focuses primarily on the relation of benefits to individual firms rather than to society as a whole.

Mishra, S. N., and John Beyer. 1976. *Cost-Benefit Analysis: A Case Study of the Ratnagiri Fisheries Project.* Delhi: Hindustan Publishing Corp.

Interesting application of benefit-cost analysis to a fisheries project.

Mulvaney, John. 1969. *Analysis Bar Charting: A Simplified Critical Path Analysis Technique.* Bethesda, Md.: Management Planning and Control Systems, Inc. (5825 Rockmere Drive, Md. 20817, U.S.A.).

Excellent, introductory text on critical path analysis technique. Uses "precedence diagramming," a method that puts activities into boxes and uses arrows to connect them; the method is more readily understood than conventional techniques using arrows to indicate activities.

Niswonger, C. Rollin, and Philip E. Fess. 1977. *Accounting Principles.* 12th ed. Cincinnati, Ohio: South-Western.

Thorough text on accounting following American conventions.

Norton, Roger D., and Leopoldo Solis M. 1982. *The Book of CHAC: Programming Studies for Mexican Agriculture.* Baltimore, Md.: Johns Hopkins University Press.

An example of a programming model applied to agricultural sector planning.

Olivares, Jose. 1978. "Evaluacion retrospectiva de proyectos agricolas" [Retrospective evaluation of agricultural projects]. Washington, D.C.: World Bank. Restricted circulation.

A discussion of World Bank agricultural project experience and reasons why some projects fall short of expectations.

Packard, Philip C. 1974. *Project Appraisal for Development Administration.* The Hague: Mouton.

Discusses the methodology of project analysis by referring to illustrative cases drawn from agroindustrial projects in developing countries.

Pouliquen, Louis Y. 1970. *Risk Analysis in Project Appraisal.* Baltimore, Md.: Johns Hopkins University Press.

Applies formal risk analysis techniques, which require machine computation, primarily to problems of transport and public utility projects. Discusses issues of suitable techniques for applying risk analysis.

Powers, Terry A. 1975. *HERDSIM Simulation Model: User Manual.* Papers on Project Analysis no. 2. Washington, D.C.: Inter-American Development Bank.

Presents and discusses a computer program for beef herd projections.

Prest, A. R., and R. Turvey. 1966. "Cost-Benefit Analysis: A Survey." In *Surveys of Economic Theory*, vol. 3, *Resource Allocation*, edited by the American Economics Association and the Royal Economic Society, pp. 155–207. New York: St. Martin's.

The best general survey with which to begin serious exploration of the issues relating to measures of project worth.

Reutlinger, Shlomo. 1970. *Techniques for Project Appraisal under Uncertainty.* Baltimore, Md.: Johns Hopkins University Press.

A sophisticated treatment of uncertainty; requires the use of a computer. Useful where very large investments are involved and suitable, highly skilled manpower can be assigned to the analysis.

Riley, J. Paul, and others. 1978. "Cost Allocation Alternatives for the Senegal River Development Program." Water Resource Planning Series no. UWRL/P-78/06. Logan: Utah State University, Utah Water Research Laboratory.

A careful discussion of joint cost allocation issues and methodologies applied to an international project in West Africa.

Ripman, Hugh. 1964. "Project Appraisal." *Finance and Development*, vol. 1, no. 3 (December), pp. 178–83.

The first published, systematic presentation of the aspects of project analysis.

Ruthenberg, Hans. 1977. "A Framework for the Planning and Evaluation of Agricultural Development Projects." Nairobi: Ministry of Agriculture, Planning Division. [Available in German as *Ein Rahmen zur Planung und Beurteilung landwirtschaftlicher Entwicklungs-projeckte.* 2. Auflage. Frankfurt: DLG-Verlag.]

A very thorough text with considerable emphasis on preparation of projects as well as a discussion of analytical techniques.

Sassone, Peter G., and William A. Schaffer. 1978. *Cost-Benefit Analysis: A Handbook.* New York: Academic.

Written for noneconomists, this is a direct statement of the elements of benefit-cost analysis. It is addressed to readers in developed rather than developing countries and is not intended to deal with a particular sector. Has a good, but not annotated, bibliography.

Schaefer-Kehnert, Walter. 1978. "Time-Adjusted Cash Flow Projections in Farm Investment Analysis." *Zeitschrift fur Auslandische Landwirtschaft* [Quarterly Journal of International Agriculture], vol. 17, no. 3 (July–September), pp. 233–49.

Discusses the rationale for the "time-adjusted" accounting convention for farm investment analysis and the incremental working capital as a percentage of incremental operating expenditure.

———. 1980. "Methodology of Farm Investment Analysis." *Zeitschrift fur Auslandische Landwirtschaft* [Quarterly Journal of International Agriculture], vol. 19, no. 2 (April–June), pp. 105–21; no. 3 (July–September), pp. 250–67.

Distinguishes farm investment analysis (benefit-cost analysis of on-farm investments) from farm income analysis and funds flow analysis and describes the accounting procedures required for a time-adjusted phasing of costs and benefits. The treatment of inflation, performance criteria, and the measurement of small farmers' investment incentives are also discussed.

———. 1981*a*. "Herd Projection Exercise. Tanzania Ranch." AE-1097-P. Washington, D.C.: Economic Development Institute, World Bank.

A self-teaching guide to herd projections that is compatible with the farm budget accounting convention recommended in this book.

———. 1981*b*. "How to Start an Internal Rate of Return Calculation." CN-30. Washington, D.C.: Economic Development Institute, World Bank.

Discusses means to estimate the internal rate of return easily to reduce the calculation burden arising from repeated trials.

Scott, M. FG., J. D. MacArthur, and D. M. G. Newbery. 1976. *Project Appraisal in Practice.* London: Heinemann.

Applies the methodology proposed by Little and Mirrlees (1974) to selected projects in Kenya. Advanced.

Shanner, W. W. 1979. *Project Planning for Developing Economies.* New York: Praeger.

A general text on the methodology of benefit-cost analysis. The book grew out of materials prepared for university instruction. Contains an analysis of a hypothetical supplemental irrigation project.

Sloan, Harold S., and Arnold J. Zurcher. 1970. *Dictionary of Economics.* 5th ed. New York: Barnes & Noble.

A standard reference for economics terms.

Squire, Lyn, and Herman G. van der Tak. 1975. *Economic Analysis of Projects.* Baltimore, Md.: Johns Hopkins University Press.

A methodology for project analysis developed by two World Bank economists and growing from that of Little and Mirrlees (1974) and the UNIDO *Guidelines* (1972*a*). Recommends a more "systematic and consistent estimation and application of shadow prices" than had previously been common in World Bank practice as well as calculation of "rates of return that take explicit account of the impact of the project on the distribution of income both between investment and consumption and between rich and poor" (p. 3).

United Nations Industrial Development Organization (UNIDO). 1972*a*. *Guidelines for Project Evaluation.* Prepared by Partha Dasgupta and others. New York: United Nations.

Proposes a methodology for project analysis that incorporates elements of more systematic shadow pricing and distribution weights. Along with Little and Mirrlees (1974), this work has exerted substantial influence on recent thinking about project analysis methodology.

———. 1972*b*. *Manual on the Use of Consultants in Developing Countries.* New York: United Nations.

Concise, comprehensive guide of immediate practical relevance to administrators in developing countries.

U.S. Government, Water Resources Council. 1979. "Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resource Planning." *Federal Register,* vol. 44, no. 242 (December 14), pp. 72892–976.

Defines costs and benefits for use by U.S. government agencies and specifies how they are to be used for evaluating water resource projects.

Upper, Jack L., ed. 1979. "Finance for Project Analysis." Washington, D.C.: Economic Development Institute, World Bank.

A collection of training materials that focus on financial analysis of industrial enterprises.

van der Tak, Herman G. 1969. *The Economic Choice between Hydroelectric and Thermal Power Developments*. Baltimore, Md.: Johns Hopkins University Press.

Discusses methodologies to analyze the choice between alternative technologies with very different time profiles for investment and operating costs.

Wall, Albert. 1979. *Environment and Development*. Washington, D.C.: World Bank.

Discusses the relation between project investment and environmental and health problems.

Ward, William A. 1976. "Adjusting for Over-Valued Local Currency: Shadow Exchange Rates and Conversion Factors." CN-28. Washington, D.C.: Economic Development Institute, World Bank.

Intended for practical application in those instances where estimates by the central planning office are not available and project analysts must determine shadow exchange rates or conversion factors for themselves.

Waterston, Albert, Wayne Weiss, and John L. Wilson. 1976. *Managing Planned Agricultural Development*. Washington, D.C.: Government Affairs Institute.

A handbook intended as a source document for those responsible for preparing agricultural projects.

Westley, Glenn D. 1981. *FARMSIM Users Guide: A Model for the Appraisal of Farm Development Projects*. Papers on Project Analysis no. 12. Washington, D.C.: Inter-American Development Bank.

Presents and discusses a computer program for appraising farm development projects.

Woo, S. J. 1982. "Sources of Information on World Prices." CN-26. Washington, D.C.: Economic Development Institute, World Bank.

Comprehensive listing of sources for obtaining world market prices to use in project analysis.

World Bank. 1978, 1980, and 1981*a*. *Annual Review of Project Performance Audit Results*. Washington, D.C.

Analyzes the strengths and weaknesses of selected World Bank projects for which loan disbursements have been completed during the year to which the report pertains. Published annually.

———. 1981*b*. *A Handbook on Monitoring and Evaluation of Agricultural and Rural Development Projects*. Washington, D.C.

Discusses the approach to monitoring and evaluation and specific problems that may be encountered in collecting and evaluating data.

———. 1981*c*. *Guidelines for the Use of Consultants by World Bank Borrowers and by the World Bank as Executing Agency*. Washington, D.C.

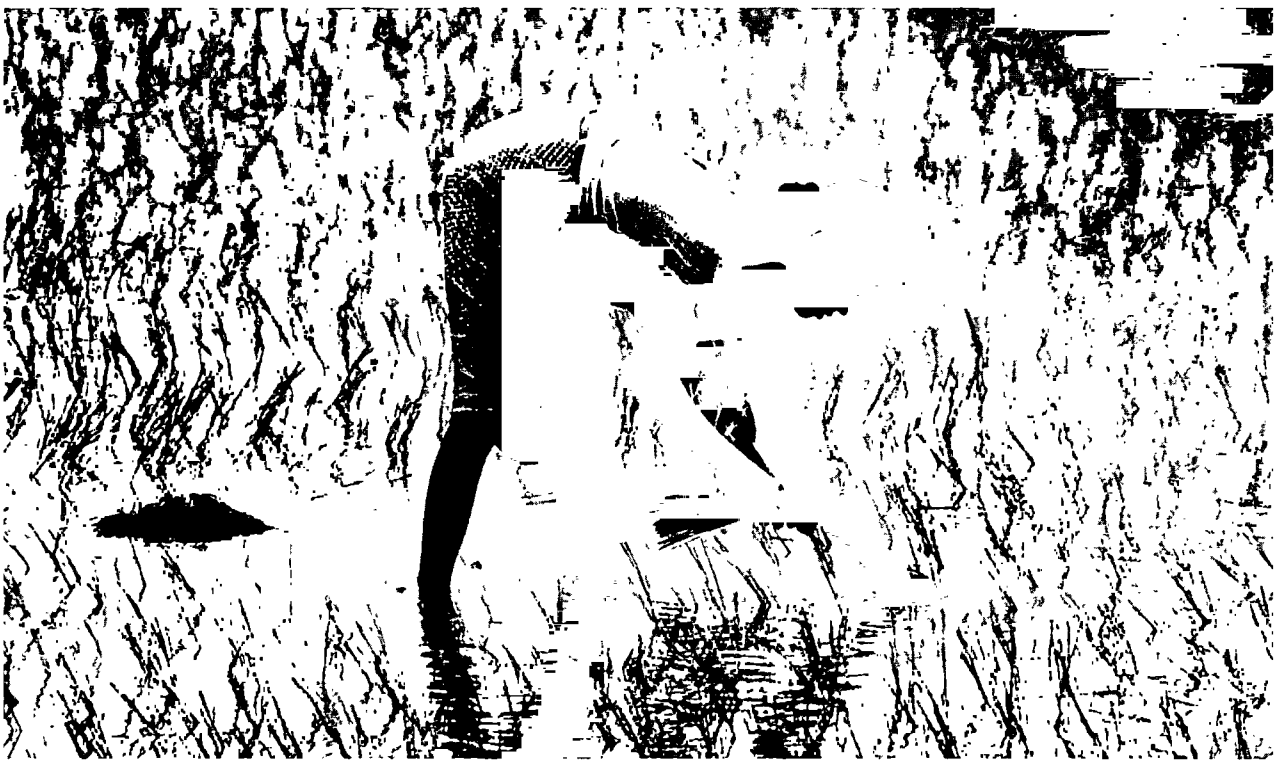
Describes the selection and supervision process, policies, and procedures relating to services of consulting firms and individual consultants used by the World Bank and its borrowers.

———. 1982*a*. *Price Prospects for Major Primary Commodities*. Report no. 814/82. Washington, D.C.

An authoritative and convenient projection of prices for major commodities of interest to developing countries. Published biennially in even-numbered years, with updates at six-month intervals between publications.

———. 1982b. "Irrigation Water Charges, Benefit Taxes, and Cost Recovery Policies." CN-88. Washington, D.C.: Economic Development Institute, World Bank.

A discussion of the concepts underlying World Bank procedures for estimating cost recovery and rent recovery indexes.



Glossary-Index

THE SPECIALIZED TERMS most frequently used in agricultural project analysis are defined in this glossary-index as they are used in this book. Definitions follow index entries and appear in *italic* type. When other terms that are also defined in the index are used in a definition or are cross-referenced, they appear in SMALL CAPITALS. For accounting terms pertaining to the financial aspects of project analysis, the reader may find Estes (1981) and Upper (1979) informative. For economic terms, the reader may also wish to consult Bannock, Baxter, and Rees (1972), Greenwald (1981), and Sloan and Zurcher (1970).

Page numbers in italic type indicate figures or tables.

Absolute value. *The numerical value of a real number irrespective of sign.*
Accounting convention (time-adjusted)
  compounding interest and, 306
  discounting and, 315
  for farm investment analysis, 95–99
  financial statements and, 190
  herd projection and, 164–65
  repayment of equal amounts of principal and, 151–53
Accounting period. *The interval between successive entries in an account. In* PROJECT ANALYSIS, *the accounting period is generally a year, but it could be any other convenient time period.*
Accounting price. *See* SHADOW PRICE
Accounts
  aggregation methods and, 287–96
  "articulated," 197
  financial statements and, 190–92
Accounts payable. *Amounts owed by an enterprise to the suppliers of goods or services purchased on credit.*
  financial rate of return calculation and, 212
  sources-and-uses-of-funds statement

Accounts payable (*continued*)
and, 199
Accounts receivable. *Amounts owed to an enterprise by its customers for purchase of goods or services provided on credit.*
balance sheet and, 193
financial rate of return calculation and, 212
sources-and-uses-of-funds statement and, 201
Accrual accounting. *A method of recording accounting transactions that records revenues in financial statements for the period during which the revenues are earned, or realized, and that records expenses in the period incurred, regardless of whether the corresponding cash transactions took place previously or subsequently. Distinguished from* CASH BASIS ACCOUNTING.
Administrators, 3
financial aspects of projects and, 18
project performance and, 33–34
project preparation and, 422–23, 426
Africa
price policy example and, 35
producer price example and, 35
social environment example and, 32
African Development Bank, 219
Aggregation. *In* PROJECT ANALYSIS, *the process of adding together the costs and benefits of all the entities participating in a* PROJECT *to reach a summary account from which a* MEASURE OF PROJECT WORTH *can be derived. Often the result of aggregation is the incremental* NET BENEFIT, *or cash flow, of a project.*
of economic values, 40
farm budget, 287–89
farm budget and declining debt service and, 138
government agencies and, 289–91
incremental net benefit and, 296
labor payments and, 294, 296
manager remuneration and, 294–95
national income measures and, 292, 293, 294, 296
processing industries and, 289
unit activity budget calculations and, 146
value added and, 293, 294
Agricultural Credit Project (Honduras), 150–51, *152*
Agricultural Minimum Package (Ethiopia), foreign exchange premium example and, 249–50
Agricultural projects. *See* Projects
Alternative cost valuation. *A technique for placing monetary values on* INTANGIBLE BENEFITS *in* MULTIPURPOSE PROJECTS. *Valid only if the alternative activity would have been undertaken in the absence of the* PROJECT. *For example, the forgone cost of drinking water wells may be used as a surrogate value for improved drinking water supplied by a multipurpose reservoir project. Used primarily in water resources projects in the United States. See* INTANGIBLE
Alto Bene Amazon Basin Project (Brazil), 257
Alto Turi Land Settlement Project (Brazil), 49–50
Amortization. *Gradual repayment or writing off of an original amount.* DEPRECIATION *is a form of amortization. The* CAPITAL RECOVERY *factor is composed of an* INTEREST *component and an amortization component.*
Amount of 1. *See* COMPOUNDING FACTOR FOR 1
Amount of 1 per annum. *See* COMPOUNDING FACTOR FOR 1 PER ANNUM
Analysis. *See* ECONOMIC ANALYSIS; FINANCIAL ANALYSIS; PROJECT ANALYSIS; SENSITIVITY ANALYSIS; Technical analysis
Animal unit. *A standard measure of feed availability or demand. In* HERD PROJECTIONS *for cattle, one animal unit is usually the* FEED REQUIREMENT *of a cow of average size in the reference area.*
defined, 103–04, 164
feed budget and, 183
herd projection and, 116–17, 174–75
labor use analysis and, 105
stable herd determination and, 178
Annual equivalent. *A* STREAM *of equal amounts paid or received annually for a period such that by* DISCOUNTING *at an appropriate* INTEREST *rate it will have a specified* PRESENT WORTH. *Determined by multiplying an initial value by the* CAPITAL RECOVERY FACTOR *for the appropriate interest rate and period. To "annualize" is to find the annual equivalent of a value.*
Annual financial equivalent (cost recovery index), 227
Annualize. *See* ANNUAL EQUIVALENT
Annuity. *An amount paid or received annually or at other regular intervals for a stated period of time. See* EQUAL INSTALLMENTS

Appraisal. *Analysis of a proposed* INVESTMENT *to determine its merit and acceptability in accordance with established decision criteria.*
Appraisal of Productive Projects in Agriculture: Economic Analysis and Rate of Return (Commission of the European Communities 1980), 438
Appraisal of projects, 24
  analysis accuracy and, 27
Arithmetic mean. *The total value of the entries in a series divided by the number of entries. The average.*
Asia, poor irrigation project planning example in, 37
Aspects of project preparation and analysis. *See* PROJECT ANALYSIS; PROJECT PREPARATION; *specific aspects of projects, e.g., economic, managerial, etc.*
Assets. *Property or claim owned by an individual or an enterprise. "Current" assets consist of cash and items expected to be converted into cash within a reasonably short period, usually one year. "Fixed" assets are durable items of relatively long life that are used by the enterprise for production of goods and services. On a* BALANCE SHEET, *"other" assets include assets such as patents and trademarks, which have no physical existence but are of value to the enterprise; investments in other companies or in securities; deferred expenses such as start-up expenses; and miscellaneous other assets peculiar to particular types of enterprises.*
  balance sheet preparation and, 192–95
  current ratios and current, 207
  incremental net benefit before financing calculation and, 212
  return on (income ratio), 207
  salvage value of capital, 118
  sources-and-uses-of-funds statement and, 198, 199, 201
Associated cost. *The value of goods and services over and above those goods and services included in the project* COSTS *incurred to make the immediate products or services of the* PROJECT *available for use or sale. Used in U.S. government practice for computing the* BENEFIT-COST RATIO *at* MARKET PRICES.
Average annual proceeds per unit of outlay, 303. *An undiscounted* MEASURE OF PROJECT WORTH. *Calculated by dividing the total net (undiscounted) value of incremental production by the number of years over which the value will be realized and then dividing the result by the undiscounted outlay for the initial* INVESTMENT.
Average income on book value of investment, 303–04. *An undiscounted* MEASURE OF PROJECT WORTH. *Average* INCOME *divided by the book value of the assets (that is, the value of the* ASSETS *after subtracting* DEPRECIATION*), stated as a percentage.*

Bacha, Edmar, 248
Balance of payments, 217
Balance sheet, 190. *For a particular time, usually the end of an* ACCOUNTING PERIOD, *a tabulation of the* ASSETS *of an enterprise in one column (on the left in American usage, on the right in British usage) and its liabilities and owners'* EQUITY *on the opposite side. These two columns are always equal, and therefore the accounting equation (assets = liabilities + owners' equity) must always hold true.*
  preparation of, 192–95
Baldwin, George B., 292
Barnum, Howard N., 259
Baseline cost. *See* COST
B/C ratio. *See* BENEFIT-COST RATIO
Benefit. *In* PROJECT ANALYSIS, *any good or service produced by a* PROJECT *that furthers the objective of the entity from whose standpoint the analysis is being undertaken. In the analytical system outlined in this book, benefits are goods and services that increase the* INCOME *of farmers or firms, or increase the* NATIONAL INCOME *of the society. When it is possible to value benefits, the increase is valued either at* MARKET PRICES *in* FINANCIAL ANALYSIS *or at* ECONOMIC VALUES *in* ECONOMIC *analysis.* INTANGIBLE *benefits cannot be incorporated in the benefit-cost framework, even though they are accepted as valuable, and so must be dealt with subjectively or indirectly, often through a* COST EFFECTIVENESS ANALYSIS. *See* Benefits
Benefit-cost ratio (B/C ratio), 299, *342. A discounted* MEASURE OF PROJECT WORTH. *The* PRESENT WORTH *of the* BENEFIT STREAM *divided by the present worth of the* COST STREAM. *For a formal mathematical definition, see the appendix to chapter 9. Often abbreviated "*B/C *ratio." Also fre-*

Benefit-cost ratio (*continued*)
quently called the "cost-benefit ratio" When the benefit-cost ratio is used, the selection criterion is to accept all INDEPENDENT *projects with a benefit-cost ratio of 1 or greater when discounted at a suitable* DISCOUNT RATE, *most often the* OPPORTUNITY COST OF CAPITAL. *May give incorrect ranking among independent projects, and cannot be used for choosing among* MUTUALLY EXCLUSIVE *alternatives.*
analysis of, 343–46
comparisons and ranking of, 358–61
computation of discounted measures and, 358
depreciaton and, 351, 355
mutually exclusive projects and, 373
net present worth and, 327
project selection and, 346, 350, 351
Benefits. *See also* Incremental net benefit; Net benefit *entries*
cost recovery example and, 224
defined, 43–47
delay (switching value method), 373
direct transfer payments and, 50–52
disadvantaged farmers and, 132
economic values determination and intangible, 279–84
electricity and, 391
future prices and inflation and, 76
housing and, 59
intangible, 61–62, 279–84
location of sale change and, 57–58
loss avoidance and, 58–59
mechanization and, 58
negative, 318
processing and grading and, 58
production increases and, 56–57
project preparation and, 427–28
quality improvement and, 57
separable costs–remaining benefits method and, 234–40
time of sale change and, 57
transport and, 58, 59
with and without comparisons and, 47–50
Benefit stream. *A series of benefit values extending over a period of time, generally several years. See* BENEFIT; STREAM
Benefit tax, 216. *A* TAX *levied in addition to charges paid directly by the beneficiary to recover* COST *and a share of incremental* BENEFIT. *In an irrigation* PROJECT, *a tax levied on project beneficiaries that is intended to recover part or all of project cost and part of the* ECONOMIC RENT *generated by the project. Commonly it takes the form of a* BETTERMENT LEVY *assessed against the land benefited; it may be varied according to the different crops grown.*
aggregation and, 290
cost recovery example and, 224, 225–26
rent recovery and, 232
Betterment levy. *A* TAX *that is assessed on project beneficiaries and is intended to recover from them some part of the* BENEFIT *generated by the* PROJECT *and realized by them. Often assessed on the basis of land areas.*
Bierman, Harold, Jr., 300
Bigg, W. W., 190
Book value. *See* AVERAGE INCOME ON BOOK VALUE OF INVESTMENT
Border price. *The unit price of a* TRADED *good at a country's border. For exports, the* F.O.B. *price; for imports, the* C.I.F. *price. See* PRICE; *compare with* FARM-GATE PRICE
foreign exchange premium and, 248
joint cost allocation and, 233
price distortions in traded items and, 251, 253
Boundary. *See* PROJECT BOUNDARY
Brazil, 10
Alto Bene Amazon Basin Project in, 257
Alto Turi Land Settlement Project in, 49–50
Ceara Rural Development Project in, 150
Breeding cow
animal units and, 174–75
computational conventions and, 165
culling rate and, 167
defined, 164
herd growth and, 179, 180, 181
ratio of bulls to, 167–74
stable herd determination and, 175, 176, 178, 179
Brown, Maxwell L., 90, 91, 141
Bruno ratio, 398. *See also* DOMESTIC RESOURCE COST
Budgets. *See also* FARM BUDGET; Feed budget; UNIT ACTIVITY BUDGET
in agricultural projects, 72
cost recovery and, 216
financial aspects of projects and, 17
steps in project analysis and, 40
Building costs (balance sheet), 193
Bulls
computational conventions and, 165
culling rate and, 166–67
defined, 164
herd growth and, 179, 180, 181

ratio of breeding females to, 167–74
stable herd determination and, 176, 178

Calculators
herd projection calculations and, 183
project analysis and, 401–08
Calf
computational convention and, 165
defined, 164
herd growth and, 179, 181
mortality, 116, 164, 165, 166, 176
stable herd determination and, 176, 177, 178, 179
Calving rates, 165, 166
Canal Lining Project (Pakistan), 48–49
Capital. *In an economic sense, goods created by the process of* INVESTMENT *that are capable of producing economic wealth. It is thus, generally,* REAL *capital. Capital in this sense is one of the three classic* FACTORS OF PRODUCTION *(along with labor and land, whose productivity capital enhances). In an accounting sense, the stock of funds and other* ASSETS *owned by an individual or an enterprise. The total funds provided by owners or shareholders plus retained earnings (that is,* EQUITY*). The excess of assets over* LIABILITIES. *See also* Incremental working capital; WORKING CAPITAL
balance sheet and share, 195
economic analysis and, 19–20
farmer's own, 129, 140
farm investment analysis and, 98–99
incremental net benefit and borrowed, 317, 318
initial expenditure of, 217
rent recovery and, 231
Capital cost to irrigation (separable costs–remaining benefits method), 240
Capitalize. *In credit transactions, to add* INTEREST *due during the* GRACE PERIOD *to the* PRINCIPAL *of a loan so that the borrower need not pay any interest during the grace period. When repayment begins, the amount borrowed plus the interest capitalized becomes the principal that must be repaid.*
Capital recovery (calculator example), 406–07
Capital recovery factor, 236. *The annual payment that will repay a loan of 1 currency unit in x years with compound* INTEREST *on the unpaid balance. Also called the "partial payment factor." The expression* $[i(1 + i)^n] \div [(1 + i)^n - 1]$ *where* i = *the rate of interest and* n = *the number of years. The reciprocal of the* PRESENT WORTH *of an* ANNUITY *factor. Generally obtained from a set of compounding and discounting tables. This factor permits calculating the* EQUAL INSTALLMENTS *necessary to repay (amortize) a loan over a given period at a stated interest rate. The total payment is a varying combination of both interest and repayment (amortization) of* PRINCIPAL. *See appendix B*
Caqueta Rural Development Project (Colombia), 257–58
Carrying capacity. *The amount of feed available from a pasture area, generally stated in* ANIMAL UNITS.
animal units and, 116–17, 174–75
feed budget and, 183
pasture and, 164, 174, 175
stable herd determination and, 175, 176, 178, 179
Cash
as current assets, 193
economic values determination and, 247
expenditures for operations, 202
rate of return and, 210
rent recovery and, 229
sources-and-uses-of-funds statement and, 201, 202
Cash accounting, 191
Cash basis accounting. *A method of recording accounting transactions only when cash receipts or expenditures occur. Distinguished from* ACCRUAL ACCOUNTING.
Cashew Project (India), 142–46, 157–58, 406
Cash flow. *See also* NET BENEFIT
discounting process and analysis of, 95
government, 217–20
incremental net benefit flow definition and, 209–10
noncash elements and, 89
Cash operating expenses
income statement and, 195–96
incremental net benefit before financing calculation and, 211
Cash position, farmer's needs and, 134
Cash (surplus or deficit), 202
government cash flow and, 220
Ceara Rural Development Project (Brazil), 150
C.i.f. (cost, insurance, and freight). *The landed* COST *of an import on the dock*

C.i.f. (*continued*)
or other entry point in the receiving country. Includes cost of international freight and insurance and often includes cost of unloading onto the dock. Excludes any charges after the import touches the dock and excludes all domestic TARIFFS *and other* TAXES *or fees. Compare with* F.O.B.
C.i.f. prices
export and import parity prices and, 78–79, 80
export and import parity values and, 269, 270, 271
indirectly traded items and, 266
price distortions in traded items and, 253
Civil engineering works, contingency allowances and, 395
Climate
poor project analysis and, 36
project preparation and, 415
Coefficient of variation. *A measure of the dispersion of a frequency distribution. Calculated by dividing the* STANDARD *deviation by the* ARITHMETIC MEAN *and multiplying the result by 100.*
Collateral. *Property pledged by a borrower to protect the interests of the lender.*
Colombia, Caqueta Rural Development Project in, 257–58
Command area. *The area that can be irrigated by a particular group of irrigation works.*
Commercial aspects of projects, 16
Commitment fee. *A fee paid by a borrower to a lender in the period between approval of a loan and disbursement of the loan. Intended to reimburse the lender for the* COST *associated with meeting a disbursement request on demand. Usually stated as a percentage of the loan amount approved and much less than the* INTEREST *rate charged for the loan commencing with disbursement.*
Committees (coordinating), 33
Compounding. *The process of finding the future value in some future year of a present amount growing at compound* INTEREST. *The future value is determined by multiplying the present amount by the expression* $(1 + i)^n$ *where* i = *the interest rate and* n = *the year. This expression is usually obtained in the form of the* COMPOUNDING FACTOR FOR 1 *from a set of compounding and discounting tables.*
Compounding and Discounting Tables for Project Evaluation (Gittinger 1973)
compounding interest and, 306–07
discounting present worth and, 308, 311, 312
equal installment repayments and, 153, *156*
internal rate of return determination and, 335
use of calculators and, 405
Compounding factor for 1. *What an initial amount of 1 becomes when growing at compound* INTEREST. *Also called the "compound interest factor" and the "amount of 1." The expression* $(1 + i)^n$ *where* i = *the interest rate and* n = *the number of years. Usually obtained from a set of compounding and discounting tables. See appendix B*
Compounding factor for 1 per annum. *Growth of equal year-end deposits of 1, all growing at compound* INTEREST. *Also called the "compound interest factor for 1 per annum" and the "amount of 1 per annum." The expression* $[(1 + i)^n - 1] - i$ *where* i = *the rate of interest and* n = *the number of years. The reciprocal of the* SINKING FUND FACTOR. *Generally obtained from a set of compounding and discounting tables. This factor permits calculating the value to which a constant amount deposited at the end of each year will grow by the end of a stated period at a stated interest rate. See appendix B*
Compound interest. *See* INTEREST
Compound interest factor. *See* COMPOUNDING FACTOR FOR 1 *and appendix B*
Compound interest factor for 1 per annum. *See* COMPOUNDING FACTOR FOR 1 PER ANNUM
Computers
herd projection calculations and, 183
project analysis and, 408
Connor, Larry J., 90
Constant. *Refers to a value, most often a* PRICE, *from which the overall effect of a general price inflation has been removed. A "constant price" is a price that has been deflated to* REAL *terms by an appropriate "price index" (a series that records changes in a group of prices relative to a given, or base, period—see index number). May refer either to a* MARKET PRICE *or a* SHADOW PRICE. *Compare with* CURRENT; *see*

Constant prices; Constant terms; REAL BURDEN OF DEBT SERVICE
Constant prices
declining real burden and, 158
farm investment analysis and, 89
predicting future prices and inflation and, 76–77
Constant terms
foreign exchange flow and, 221
government cash flow projections and, 217
Construction
balance sheet calculation and, 195
farm investment and, 121
residual value and, 119
Construction costs, 53, 235, 239
sensitivity analysis and, 365
Consultants
administrative problems and, 33
farm investment analysis and, 92
financial statements and, 192
project preparation assistance and, 441–43
Consumption value. *See* VALUE IN USE
Contingency allowance. *An amount included in a project account to allow for adverse conditions that will add to baseline* COSTS. *Physical contingencies allow for physical events such as adverse weather during construction; they are included in both the* FINANCIAL *and the* ECONOMIC ANALYSIS. *Price contingencies allow for general inflation; in* PROJECT ANALYSIS *they are omitted from both the financial and the economic analysis when the analysis is done in* CONSTANT *prices.*
agricultural credit projects and, 394
costs and, 393, 394, 395
inflation and, 393–94, 395
physical, 53–54, 359
price, 53–54, 393–94, 395
price change and, 393–94, 395
project analysis and, 394–95
project costs and, 53–54
project preparation and, 421
Conventions, accounting. *See* Accounting convention (time-adjusted)
Conversion factor. *A number, usually less than 1, that can be multiplied by the domestic* MARKET PRICE, OPPORTUNITY COST, *or* VALUE *in use of a* NONTRADED *item to convert it to an equivalent* BORDER PRICE *that reflects the effect of trade* DISTORTIONS *on domestic prices of that good or service. A standard conversion factor is the reciprocal of 1 plus the* FOREIGN EXCHANGE PREMIUM *stated in decimal form.*
Conversion factor approach
foreign exchange premium and, 248–49, 254
import parity value and, 270
indirectly traded items and, 266, 267–69
Cooperatives
project preparation and, 424
sharing bulls and, 174
Coordinating committees, 33
Cost. *In* PROJECT ANALYSIS, *any good or service a* PROJECT *uses that reduces progress toward the objective of the entity from whose standpoint the analysis is undertaken. In the analytical system outlined in this book, costs are goods and services that reduce the* INCOME *of farmers or firms, or reduce the* NATIONAL INCOME *of the society. When it is possible to value a cost, it is valued at* MARKET PRICES *in* FINANCIAL ANALYSIS *or at an* ECONOMIC *value in economic analysis.* INTANGIBLE *costs cannot be incorporated in the benefit cost framework, even though they are accepted as important, and so must be dealt with subjectively, or indirectly, often through a* COST EFFECTIVENESS ANALYSIS. *"Baseline costs" are costs at some period at or before the beginning of a project and become the basis for later evaluation of the effects of the project. See* Costs, Cost *entries*
Cost allocation (joint)
general principle of, 233–34
separable costs–remaining benefits method and, 234–40
Cost-benefit ratio. *See* BENEFIT-COST RATIO
Cost effectiveness, 280
Cost effectiveness analysis. *An* APPRAISAL *and program-monitoring technique used primarily in social* PROGRAMS *and* PROJECTS *in the health, population, nutrition, and related sectors in which* BENEFITS *cannot be reasonably measured in* MONEY TERMS. *It may also be used to choose among technologies considered for use within a project. Cost effectiveness analysis is used in two forms: (1) the "constant effects" method, which uses least-cost analysis to determine the least-cost alternative for meeting a stated level of benefits, including* INTANGIBLE *benefits; and (2) the "constant cost" method, which calculates the cost per unit of benefit, or the "cost effectiveness ratio," and requires that means*

Cost effectiveness analysis (*continued*)
exist for quantifying benefits (but not necessarily for attaching a monetary price or economic value to the benefits). Quantitative measures such as "couple-years-of-protection" (CYP) *are used in population projects, for example, to quantify project* OUTPUTS *rather than to place monetary values on the outputs. The preferred project alternative usually either minimizes the discounted* PRESENT WORTH *of cost per unit or maximizes the discounted present worth of units of output per unit of currency. The* DISCOUNTING *is normally done at the* OPPORTUNITY COST OF CAPITAL *or the* CUT-OFF RATE. *If cost effectiveness analysis is used within a project to choose among alternative technologies to determine the most cost effective means to produce intermediate project outputs, it is most often done in the form of the constant effects method and called "least-cost analysis." The preferred alternative is the one that has the lowest present worth, and the preference may change when different* INTEREST *rates are used to determine the present worth. The interest rate at which the present worths of two different alternatives are the same (and, hence, the analyst is indifferent between alternatives on cost grounds) is known as the* CROSSOVER DISCOUNT RATE. *It is impossible to obtain a* MEASURE OF PROJECT WORTH *from cost effectiveness analysis since the analysis is done without reference to the value to users of the project output*
Cost estimates
project preparation and, 420–21
sensitivity analysis and, 364–65
Cost, insurance, and freight. *See* C.I.F., C.i.f. prices
Cost overruns, 27
consultants and, 443
project delays and, 29
sensitivity analysis and, 364, 365–71
Cost recovery
benefit taxes and water charges and, 225–26
government receipts and expenditures and, 215–17
measuring, 226–28
measuring rent recovery and, 228–32
objectives of, 223–24
overview of policy for, 222–23
project preparation and, 426–27
Cost recovery index. *The proportion of project* COST *recovered from project beneficiaries. In an irrigation* PROJECT, *the ratio of the* PRESENT WORTH *of incremental water charges plus the present worth of incremental* BENEFIT TAXES *divided by the present worth of incremental public sector outlays and stated in percentage terms. Calculated at* CONSTANT, MARKET PRICES.
Costs
balance sheet preparation and, 193
consultant use and overruns of, 442–43
contingency allowances and, 53–54, 393–95
cost recovery example and, 224, 226–28
debt service and, 54–55
defined, 43–47
delays and increases in, 28–29
direct transfer payments and, 50–52
domestic resource, 398–400
economic values determination and intangible, 279–84
future prices and inflation and, 76
government receipts and expenditures and, 215, 216, 217
intangible, 61–62, 279–84
labor, 53
land, 53
physical goods, 52–53
poor project analysis and estimating, 35–36
project preparation and, 421–22
replacement, 395–97
secondary, 59–61
sensitivity analysis and estimating, 364–65
separable costs–remaining benefits method and, 234–40
sunk, 55
taxes and, 54
with and without comparisons and, 47–50
Costs and benefits analysis, 19
Cost stream. *A series of* COST *values extending over a period of time, generally several years. See* COST; STREAM
Cotton Processing and Marketing Project (Kenya), 371–73
Credit *See also* DEBT SERVICE; Loans
computing debt service and, 147
contingency allowances and, 394
direct transfer payments and, 52
discounting assumptions and, 99
financial aspects of projects and, 17
financial price adjustments (transfer payments) and, 251
poor project analysis and, 31, 32

project delays and projects for, 29
project preparation and, 419, 423
simple interest calculations and, 147–50
sources-and-uses-of-funds statement and, 202
unit activity budget and, 146
Creditworthiness. *The ability of an individual, firm, or nation to meet its* DEBT SERVICE *obligations. For a firm, a judgment about creditworthiness is often formed on the basis of one or another* FINANCIAL RATIO.
Creditworthiness ratio, 191, 207–09
Critical path diagram. *A diagram that plots the sequence of activities for project planning and scheduling, shows which activities must be completed before others can commence, and indicates which activities cannot be delayed without delaying the whole* PROJECT. *Variously referred to as "critical path method"* (CPM), *"program evaluation and review technique"* (PERT), *or "network analysis." See Mulvaney (1969).*
Cropping intensity. *Total cultivated area on a farm divided by total cropland. When there is* MULTIPLE CROPPING, *the cropping intensity may be greater than 1. Often reported as a percentage. Thus, a farm where 7 hectares are cultivated as a result of multiple cropping, but where there are only 5 hectares of total cropland, has a cropping intensity of 1.4 (7 ÷ 5 = 1.4), or 140 percent.*
Cropping pattern. *The area devoted to, and the sequence of, crops produced by a farmer or in a region.*
Cropping patterns
climate and, 415
computer use and, 408
family labor and, 139
farm investment analysis and, 90, 91, 92, 93
land use analysis and, 100–01
project preparation and, 415–16, 418
unit activity budgets and, 142
with and without project and, 138
Crops
budgets (aggregation) and, 287–89, 291
climate and poor project estimates for, 36
inappropriate technology and, 30
incremental working capital for, 127
labor use analysis and, 102–03, 105, 111
land use analysis and, 100–01
operating expenditure and, 98, 123
projected farm production and, 112, *113*
response to nitrogen fertilizer example (Philippines) and, 65–69
separable costs–remaining benefits method and, 234
unit activity budgets and, 141, 142
Crossover discount rate, 383–88. *The* DISCOUNT RATE *that equalizes the* PRESENT WORTHS *of the* COST STREAMS *of two alternatives producing the same result. Usually used to choose between two technological alternatives or alternative project designs having different time streams. The preferred alternative is the one with the lowest present worth. At some discount rate, alternatives having different time streams may have equal present worths; at a higher discount rate, a different alternative is preferred from that below the rate. Also called the "equalizing discount rate."–May be determined graphically by plotting the present worth of the two alternatives at different discount rates or may be computed by finding the* INTERNAL RATE OF RETURN *to the differences year by year between the cash flows of the alternative with the higher undiscounted* COST *less the alternative with the lower undiscounted cost.*
Cull. *In livestock husbandry, to remove as a result of failure to meet a standard. Culled animals are animals removed from a herd because they do not meet performance standards. A culling rate is the proportion of animals of a class removed for failure to meet performance standards; it is generally stated as a percentage.*
Culled animals
defined, 164
rates of, 166–67
Cultural environment, 91
Cumulative surplus (deficit). *In a government cash flow account for a* PROJECT, *the difference between cash* INFLOW *and cash* OUTFLOW *from the beginning of the project through a given year. Compare with* CURRENT SURPLUS (DEFICIT)
Currency
economic values determination and domestic, 244
foreign exchange premium and domestic, 247

Current. *Refers to a value, most often a* PRICE, *that includes the effects of general price* INFLATION. *A past value or price as actually observed; a future value or price as expected to occur. Compare with* CONSTANT. *In economic literature, a constant price is usually specified if it is intended; otherwise, one infers that a current price is intended. See* Current costs; Current prices; CURRENT RATIO; Current terms
Current costs, project preparation and, 422
Current prices
farm investment analysis and, 89
measures of project worth and, 400–01
predicting future prices and inflation and, 76–77
Current ratio, 207–08. *Current* ASSETS *divided by current* LIABILITIES. *A* FINANCIAL RATIO *used to judge* LIQUIDITY *or* CREDITWORTHINESS.
Current surplus (deficit). *In a government cash flow for a* PROJECT, *the difference between cash* INFLOW *and cash* OUTFLOW *for any given year. Compare with* CUMULATIVE SURPLUS (DEFICIT)
Current terms
foreign exchange flow and, 221
government cash flow projections and, 217
Cut-off rate, 314, 381. *The rate below which a* PROJECT *is considered unacceptable. Often taken to be the* OPPORTUNITY COST OF CAPITAL. *The cut-off rate would be the minimum acceptable* INTERNAL RATE OF RETURN *for a project or the* DISCOUNT RATE *used to calculate the* NET PRESENT WORTH, *the* NET BENEFIT-INVESTMENT RATIO, *or the* BENEFIT-COST RATIO.
Cycle of projects, 21–26

Data
discount measure computation and, 356–57
project format and, 8
Debt-equity ratio, 208. [LONG-TERM LIABILITIES ÷ *(long-term liabilities +* EQUITY)] – [*Equity ÷ (long-term liabilities + equity)*]. *Usually stated as the first bracketed part of the equation compared with the second bracketed part of the equation, with both parts multiplied by 100, in a ratio such as 60.40. A* FINANCIAL RATIO *used to determine the degree of* LEVERAGE *and to help form judgments about risk and* CREDITWORTHINESS.
Debt service. *A payment made by a borrower to a lender. May include one or all of: (1) payment of* INTEREST; *(2) repayment of* PRINCIPAL; *and (3) loan* COMMITMENT FEE. *See also* EQUAL INSTALLMENTS; Credit; Loans
computation of, 147–62
declining real burden assumption and, 158–62
direct transfer payments and, 50
equal installments calculations and, 153–58
farm budget and, 129, 133–38
financial planning and, 87
foreign exchange flow and, 222
government cash flow and, 219, 220
project costs and, 54–55
repayment of equal amounts of principal and, 150–53
simple interest calculations and, 147–50
sources-and-uses-of-funds statement and, 202
unit activity budget calculations and, 146
Debt service coverage ratio, 209
Debt service ratio. *(Net* INCOME + DEPRECIATION + INTEREST *paid) ÷ (interest paid + repayment of* LONG-TERM *loans). A* FINANCIAL RATIO *used to judge* CREDITWORTHINESS.
Decisionmaking process, 94
sensitivity analysis and, 369
Decision tree (economic values determination), *282–83*, 284. *The diagram used in an analytical technique by which a decision is reached through a sequence of choices between alternatives. So called because the diagram resembles a tree lying on its side.*
Declining real burden of debt service. *See* REAL BURDEN OF DEBT SERVICE
Decomposition. *In* ECONOMIC ANALYSIS, *the process of separating out the constituent elements of a value; for example, determining the value of the* TRADED *and* NONTRADED *proportions of an* INDIRECTLY TRADED *item.*
Deflation. The act of adjusting CURRENT *prices to* CONSTANT *prices. The arithmetic (division) is the same as for* DISCOUNTING.
Delays (project)
implementation and, 28–29, 36
procurement problems and, 33

sensitivity analysis and, 364, 369–71
Demand, market price as estimate of economic value and, 255
Depreciation. *The anticipated reduction in the value of an* ASSET *over time that is brought about through physical use or obsolescence. In accounting, depreciation refers to the process of allocating a portion of the original* COST *of a fixed asset to each* ACCOUNTING PERIOD *so that the value is gradually used up ("written off") during the course of the asset's estimated "useful life." Allowance may be made for the ultimate estimated resale value of the fixed asset (its* RESIDUAL VALUE*) to remain at the end of its useful life to the enterprise. There are two principal types of depreciation methods: "straight-line" depreciation, which allocates the cost of a fixed asset in equal amounts for each accounting period, and "accelerated" depreciation, which allocates a larger proportion of the original cost to earlier accounting periods and a smaller proportion to later periods. In* DISCOUNTED CASH FLOW ANALYSIS *depreciation is not treated as a cost. Instead, the cost of an asset is shown in the year it is incurred, and the* BENEFITS *are shown in the year they are realized. Since this is done over the life of the* PROJECT*, no depreciation allowance is needed to show the proportion of the value of the asset used in any given year.*
accumulated allowances (balance sheet) for, 195
discounted measures and, 351–55
farm income analysis and, 89
financial rate of return calculations and, 210
incremental net benefit derivation and, 316–17
mutually exclusive projects and, 382
operating income before (sources-and-uses-of-funds statement), 198
rent recovery and, 229
"straight-line," 196
Developing countries
planning economic growth for, 6–7
UNDP assistance and, 438–39
Development
project preparation and, 413
projects as initiative for, 11
rural projects and, 15
Development period. *With respect to a* PROJECT*, the period after the* INVESTMENT PERIOD *when production builds up toward* FULL DEVELOPMENT*. In agricultural projects, often three to five years, but may be longer if the project involves cattle herds, tree crops, or other* INVESTMENTS *with long gestation.*
Direct tax. *See* TAX
Direct transfer payment. *See* TRANSFER PAYMENT
Disbursement period (project preparation), 419–20
Discounted cash flow analysis. *Analysis based on the net incremental* COSTS *and* BENEFITS *(see* NET BENEFIT*) that form the incremental cash flow. It yields a discounted* MEASURE OF PROJECT WORTH *such as the* NET PRESENT WORTH, INTERNAL RATE OF RETURN, *or* NET BENEFIT-INVESTMENT RATIO.
Discounted measure of project worth. *See* MEASURE OF PROJECT WORTH
Discounted measures. *See also* BENEFIT-COST RATIO (B/C RATIO); INTERNAL RATE OF RETURN (IRR); MEASURES OF PROJECT WORTH; NET BENEFIT-INVESTMENT RATIO (N/K RATIO); NET PRESENT WORTH
application of, 350–51
choice of, 313–15
comparisons of, 358–61
computation of, 356–58
mathematical formula for, 361
practical considerations concerning, 299–300, 308–09, 313
project life and, 355–56, *357*
time value of money and, 313–15
Discount factor. *How much 1 at a future date is worth today. Also called the "present worth factor" and the "present worth of 1." The expression* $1 \div (1 + i)^n$ *where* i = *the rate of* INTEREST (DISCOUNT RATE) *and* n = *the number of years. The reciprocal of the* COMPOUNDING FACTOR FOR 1*. Generally obtained from a set of compounding and discounting tables. This factor permits determining the value today of an amount received or paid out in the future. The process of finding the* PRESENT WORTH *of some future value is generally referred to as* DISCOUNTING*. Since the discount factor is the reciprocal of the compounding factor for 1, it is common to hear expressions such as "discounted at an interest rate of 14 percent." See appendix B*
calculator example of, 406
project life and, 356

Discount factor for a stream of income. *See* PRESENT WORTH OF AN ANNUITY FACTOR

Discounting. *The process of finding the* PRESENT WORTH *of a future amount. The present worth is determined by multiplying the future amount by the expression* $1 \div (1 + i)^n$ *where* i = *the* DISCOUNT RATE (INTEREST rate) *and* n = *the year. Generally this expression is obtained in the form of a* DISCOUNT FACTOR *from a set of compounding and discounting tables. The concept underlying discounting is sometimes referred to as the* TIME VALUE OF MONEY.
- aggregation and, 291
- investment at beginning of the year and, 99
- project life and, 355–56, *357*
- rent recovery and, 232
- time value of money dimension of, 304–15
- used in cash flow analysis, 95

Discounting tables, 431–35. *See also Compounding and Discounting Tables for Project Evaluation* (Gittinger 1973)

Discount rate, 350, 386. *The* INTEREST *rate used to determine the* PRESENT WORTH *of a future value by* DISCOUNTING.

Distortion. *A state in which the* MARKET PRICE *of an item differs from the* PRICE *it would bring in the absence of government restrictions. In* PROJECT ANALYSIS, *the principal distortion considered is the trade* TARIFF, *which permits domestic market prices to exceed* BORDER PRICES *(allowing for domestic transfer costs).*

Distribution weight. *The relative importance attached to various* INCOME *groups among the beneficiaries of a* PROJECT. *Income received by one or another group is adjusted by the weight so that the final* MEASURE OF PROJECT WORTH *will favor those groups accorded greater importance. See Squire and van der Tak (1975). Compare with* SAVINGS WEIGHT

Diverted exports *A project* INPUT *that would have been exported had there been no* PROJECT. *See* TRADED

Dividend. INCOME *distributed to shareholders of an enterprise.*

Djatiluhur Irrigation Project. *See* Jatiluhur Irrigation Project (Indonesia)

Domestic prices, 425–26

Domestic resource cost, 398–400. *The* COST *in domestic currency required to earn a unit of* FOREIGN EXCHANGE *through a proposed* PROJECT. *In* DISCOUNTED CASH FLOW ANALYSIS, *the* PRESENT WORTH *of the domestic currency cost of realizing a foreign exchange saving divided by the present worth of the net foreign exchange saving A project is accepted if the domestic resource cost is less than the* OFFICIAL EXCHANGE RATE *in* FINANCIAL ANALYSIS *or less than the* SHADOW EXCHANGE RATE *(or the reciprocal of the* STANDARD CONVERSION FACTOR*) in* ECONOMIC ANALYSIS. *Also called the "Bruno ratio." Initially formulated as an undiscounted measure based on a single year.*

Domestic value added. *The value added to a product by local or domestic activities. In an* INDIRECTLY TRADED *item, domestic value added is the total value of the product less the* BORDER PRICE *of imported components. See* VALUE ADDED

Doukkala II Irrigation Project (Morocco), 150

Drought Prone Areas Project (India), 289

Duties
- income statement and, 197
- incremental net benefit before financing calculation and, 212

Duty. *A* TAX *levied on an import.*

Early Crop Maize Project (Nigeria), 80–82, *83*, 271, *276–77*

Earnings (retained), 195

East African producer price example, 35

Economic account, valuing labor and, 258, 259

Economic analysis. *Analysis done using* ECONOMIC VALUES. *In general, economic analysis omits* TRANSFER PAYMENTS *(including credit transactions) and values all items at their* VALUE IN USE *or their* OPPORTUNITY COST *to the society (often a* BORDER PRICE *for* TRADED *items)*
- cut-off rate and, 314
- debt service and, 55
- discount factors and, 355–56, 357
- discount measure selection and, 359
- economic values and, 244, 245, 246
- financial analysis as complement to, 18
- financial prices and, 243
- foreign exchange premium and, 248
- incremental net benefit derivation and, 317–18
- price systems used in, 69
- project analysis accuracy and, 27–28

project aspects and, 19–21
project objectives and, 46
secondary costs and benefits and, 59–60
sensitivity analysis and, 363
taxes and, 54
Economic efficiency, cost recovery and, 223–24
Economic growth
economic analysis and, 21
planning, 6–7
Economic life. *The period during which a fixed* ASSET *is capable of yielding services to its owner. Distinguished from "physical life," a period often longer, during which a fixed asset can continue to function notwithstanding its acquired obsolescence, inefficient operation, high cost of maintenance, or obsolete product.*
Economic rate of return. *The* INTERNAL RATE OF RETURN *calculated using* ECONOMIC VALUES. *The internal rate of return used in* ECONOMIC ANALYSIS. *See* INTERNAL RATE OF RETURN. *See also* RATE OF RETURN
aggregation and, 291
discount measures computation and, 357–58
internal rate of return and, 331
mutually exclusive projects and, 379–81, 383
project analysis accuracy and, 27–28
sensitivity analysis and, 364
Economic rent, 231–32. *The return for the use of a* FACTOR OF PRODUCTION *in excess of the minimum required to bring forth the service of the factor. The surplus remaining to a project beneficiary after he receives the rewards necessary to attract physical* INPUTS, *labor, entrepreneurship, and the willingness to bear risk.*
Economic value. *The amount by which production of a project* OUTPUT *or use of a project* INPUT *changes* NATIONAL INCOME *(or other national objective in* PROJECT ANALYSIS*). May be a* MARKET PRICE *or may be an estimate of* VALUE IN USE *or* OPPORTUNITY COST *that differs from the market price, in which case it is a* SHADOW PRICE. *In general in this book, the term "value" is used to distinguish amounts discussed in connection with* ECONOMIC ANALYSIS *from amounts discussed in connection with* FINANCIAL ANALYSIS *(these latter amounts are referred to as* FINANCIAL *or* MARKET PRICES*).*
Economic values
decision tree for, *282–83*, 284
export and import parity values and, 252, 269–71
financial price adjustment and, 251–71
foreign exchange premium and, 247–50
indirectly traded items and, 265–69
intangible costs and benefits and, 279–84
nontraded items and, 253–65
overview of, 243–47
traded goods and, 251–53
trade policy changes and, 271–78
transfer payments and, 251
Ecuador, Livestock Development Project in, 57
Educational benefits, 280
Efficiency (economic), cost recovery and, 223–24
Efficiency price. *An* ECONOMIC VALUE *used in* ECONOMIC ANALYSIS *that reflects the* OPPORTUNITY COST *or* VALUE IN USE *of a good or service used or produced by a* PROJECT. *It may be a* MARKET PRICE *or* SHADOW PRICE. *Efficiency prices are the values used in economic analysis when the objective is to maximize* NATIONAL INCOME *(the objective assumed in this book). Hence, economic analysis done using efficiency prices is sometimes called "efficiency analysis." When the objective of a project is something other than national income (as might be the case in analyses that formally incorporate* INCOME DISTRIBUTION *or savings objectives), the efficiency price may be adjusted by an appropriate* DISTRIBUTION WEIGHT.
Efficiency prices
cost recovery and, 224
cut-off rate and, 314
economic values determination and, 244, 245, 246
foreign exchange premium and, 249
incremental net benefit and, 129
Efficiency ratio, 191, 203–06
Egypt
Lower Egyptian Drainage Project in, 59
valuing labor and, 262
Electricity, 234
indirectly traded items calculations and, 267
least-cost combination method and, 280–81, 281–84
project purpose and choice and, 391–93
Employment
project preparation and, 427
valuing labor and, 258, 261

Energy, predicting future prices and, 75
Environmental impact, 15–16
  project preparation and, 422
Equal installments. *The amount of* DEBT SERVICE *when a loan is repaid in a series of payments of the same total amount but of varying proportions of* PRINCIPAL *and* INTEREST. *The equal installment is computed by multiplying the principal by the* CAPITAL RECOVERY FACTOR. *Also called a "level payment" or an "equated annuity."*
Equalizing discount rate. See CROSSOVER DISCOUNT RATE
Equated annuity. *See* EQUAL INSTALLMENTS
Equipment
  balance sheet preparation and, 195
  contingency allowances and, 395
  cost estimates and, 365
  farm investment and, 121
  market price determinations and, 70
  operating expenditure and, 123, 126
  procurement procedures and, 16
  project preparation and, 418–19
  residual value and, 119
Equity. *An ownership right or risk interest in an enterprise. Equity* CAPITAL *is the residual amount left after deducting total* LIABILITIES *(excluding stockholders' claims) from total* ASSETS. *Return to equity is an amount received by an equity owner that is usually expressed by one or another* MEASURE OF PROJECT WORTH. *In a* BALANCE SHEET, *owners' equity is the* SHARE CAPITAL *paid in by the owners of enterprise plus* RETAINED EARNINGS. *See* CAPITAL
  debt-equity ratio and, 208
  financial rate of return to, 209, 212
  owners', 192, 193, 195, 197
  return on (income ratio), 207
  South Nyanza example (sources-and-uses-of-funds statement), 198
Espadas, Orlando T , 183
Ethiopia, Agricultural Minimum Package Project in, 249–50
European Community, 438
Evaluation
  benefit-cost ratio and, 346
  of past investment, 55
  project cycle and, 25–26
Evapotranspiration. *Loss of water from soil due both to evaporation and to transpiration from the plants growing in the soil.*
Excess capacity. *The capability of an enterprise to produce more product without any additional fixed* COST. *The economic cost of the* OUTPUT *may then be taken to be equal to the variable cost necessary for the production. More common in industrial than in agricultural projects.*
  financial price adjustment (nontraded items) and, 263
  secondary costs and benefits and, 61
Exchange rate, 400
  economic values determination and, 244
  foreign exchange premium and shadow, 248–49
  indirectly traded items and shadow, 266, 267, 269
Expansion (project facilities), 191
Expatriate. *A national of one country who is living in another country*
Expenditures, separable costs–remaining benefits method, 238. *See also* Operating expenditures
Export parity price, 80–82. *See also* TRADED
Export parity values, 252, 269, 271, *272–75*
Exports, 216
  foreign exchange premium and, 248
  indirectly traded items and, 269
  price distortions in traded items and, 251–53
  tradable but nontraded items and, 265
  trade policy change and, 277, 278
Extension (agricultural). *A service directed toward informing farmers about new agricultural technology, techniques, practices,* PRICE *changes, and the like*
Extension services
  intangible benefits and, 281
  poor project analysis and, 31–32
  project preparation and, 424
  sensitivity analysis and, 365
Externality. *In* PROJECT ANALYSIS, *an effect of a* PROJECT *felt outside the project and not included in the valuation of the project In general, economists consider an externality to exist when production or consumption of a good or service by one economic unit has a direct effect on the welfare of producers or consumers in another unit. Externalities may be either technological or pecuniary. An example of a technological externality might be silting downstream caused by opening a land settlement project or training of project workers who subsequently can be employed by others Project analysis usually tries to incorporate technological externalities, especially costs, within the project accounts and*

thus to change them from externalities to project COSTS *and* BENEFITS *For example, the increased cost of harbor dredging caused by increased siltation might be calculated and assigned to the land settlement project. Pecuniary externalities arise when the project affects the* PRICES *paid or received by others outside the project—for example, when higher prices must be paid by other users of fertilizer as a result of increased demand by project farmers. Pecuniary externalities are usually excluded from both project* FINANCIAL *and* ECONOMIC ANALYSIS.

Factor of production. *An* INPUT *required to produce* OUTPUT. *Primary factors of production are land, labor, and* CAPITAL; *secondary factors include materials, irrigation pumps, and the like.*
Families. *See* Farm families
Family labor. *In agricultural* PROJECTS, *the labor of the farmer and members of the family resident on the farm. Family members may work somewhere other than the farm, in which case the* INCOME *they earn may be* OFF-FARM *income. Compare with* HIRED LABOR
  farm budget and, 138–39
  farm investment and, 123
  farm investment analysis and, 90
  labor use analysis and, 103, 105, 111
  project costs and, 53
  rent recovery and, 229
  unit activity budgets and, 142, 146
  valuing labor and, 259, 260, 261
FAO. *See* Food and Agriculture Organization of the United Nations (FAO)
Farm budget. *In* FARM INVESTMENT ANALYSIS, *a projection of the* INFLOW *and* OUTFLOW *of a farm to estimate the incremental* NET BENEFIT *over the life of a* PROJECT. *Generally based on a* PATTERN FARM PLAN. *See also* Budgets
  aggregating, 287–89
  calculator use and, 406–07
  debt service and, 133–38, 147
  declining real burden of debt service and, 159
  family labor costs and, 138–39
  farm investment analysis and, 89
  feed requirement analysis and, 187
  incremental net benefit and, 127–32, 133
  land costs and, 139–40
  loan receipts and, 132–33, 134
  net benefit increase and, 140
  partial budgeting technique and, 91, 141
  pattern farm investment analysis and, 90, 93–94
  preparation of, 127–40
  project preparation and, 418
  taxes and, 133
  valuing labor and, 260
  valuing land and, 256
  whole farm, 287–89
Farmers, 17
  aggregation methods and, 289
  benefits and, 56–57
  benefits and disadvantaged, 132
  cash position and, 134
  cost recovery and, 224, 225, 427
  debt services and, 135
  financial impact and, 86
  harvesting practices of Javanese small, 259
  interviewing, 92
  net benefit increase and, 140–41
  objectives and, 44, 45
  organization of, 31, 424
  poor project analysis and, 31
  projected rate of return and poor, 27
  rent recovery and, 229
  resource use (own) and, 129, 140
  separable costs–remaining benefits method and, 240
  sharing of bulls and, 174
  valuing land and, 256–57
Farmers' Fertilizer Cooperative (India), 400
Farm families. *See also* FAMILY LABOR
  cropping patterns and, 139
  financial aspects of projects and, 17
  financial incentives and, 129
  home-consumed production and, 56
Farm family net benefit. *The* NET BENEFIT *of a farm family. "Incremental farm family net benefit" is the incremental net benefit.*
Farm gate. *The boundary of a farm. The farm-gate* PRICE *is the price a farmer receives for his product or pays for* INPUTS *at the boundary of the farm—that is, the price without any transport to a market or other marketing service. Most commonly applied to* OUTPUTS. *See* Farm-gate price
Farm-gate price
  determining market prices and, 70–71
  economic import parity value and, 270
  export and import parity prices and, 78, 81
  feed budget and, 187
  operating expenditure calculation and, 123
  rent recovery computation and, 229

Farm-gate price (*continued*)
valuation and, 117, *118*
Farm income *See also* INCOME
analysis of, 89
discounting assumptions and, 99
financial aspects of projects and, 17
net benefit increase and, 140–41
project preparation and, 426
unit activity budget and, 141
variations in, 91
Farm income analysis. *An analysis of a farm to check the current performance of the farm. It is usually undertaken for a one-year period (and so is undiscounted), uses* CURRENT *prices, includes an annual* DEPRECIATION *charge, excludes* OFF-FARM *income, and includes* HOME-CONSUMED PRODUCTION. *The performance criteria are the return to the* CAPITAL *and labor engaged on the farm as indicated by profit as a percentage of net worth and family* INCOME. *Distinguished from* FUNDS FLOW ANALYSIS *and* FARM INVESTMENT ANALYSIS.
Farming systems, project preparation and, 415–16
Farm investment analysis. *An analysis of a farm to determine the attractiveness of additional* INVESTMENT *in the farm. It is usually undertaken for the life of the investment and is therefore discounted, uses* CONSTANT *prices, treats* CAPITAL *by showing the initial investment in the year it is anticipated and by including* RESIDUAL VALUE *at the end of the period analyzed, includes cash and noncash farm* INCOME, *and includes* HOME-CONSUMED PRODUCTION. *The performance criterion is the return to the additional resources engaged as indicated by the* NET PRESENT WORTH, INTERNAL RATE OF RETURN, NET BENEFIT-INVESTMENT RATIO, BENEFIT-COST RATIO, *or* NET BENEFIT INCREASE. *See also* INVESTMENT
accounting convention for, 95–99
animal units definition and, 174–75
computational convention in herd projection and, 164–65
debt service computation and, 147–62
declining real burden of debt service and, 159–62
equal installments calculations and, 153–57
family labor costs and, 138–39
farm budget and, 127–40
farm production (projected) and, 111–19
feed budget (herd projection) and, 183–87
flow chart for, 95, *97*
herd growth and, 179–83
herd projection and, 113–15, 162–93
herd projection work sheet and, 165, 166, *168–73*
herd stabilization and, 175–79
incremental residual value and, 117–19
incremental working capital and, 126–27
investment and, 119–23
labor use and, 102–11
land costs and, 139–40
land use and, 99–101
livestock and, 112–17, 163
machine computation (herd projection) and, 183
net benefit increase and, 140–41
operating expenditure and, 123–26
preparing, 89–94
principal elements of, *96*
principal repayment and, 150–53
simple interest calculation and, 147–50
technical coefficients (herd projection) and, 165–80
unit activity budgets and, 141–47
valuation of production and, 117
Farms. *See also* Pattern farms
farm investment analysis and size of, 90–91
herd projection and small, 163
Feasibility study, 22–23 *A study of a proposed* PROJECT *to indicate whether the proposal is attractive enough to justify more detailed preparation. Of limited detail, but the amount of detail included in feasibility studies varies widely.*
Feed budget, 183–87
Feed concentrates, 117
Feed consumption, 112
Feed requirements
animal units and, 103–04, 174, 175
feed budget and, 183, 185–87
Fertilizer, 15
crop response to nitrogen (Philippine example) and, 65–69
inappropriate technology and, 30
trade policy change example and, 277–78
Fess, Philip E., 190
Final. *With reference to goods and services, those goods and services that are sold to the ultimate purchaser to be used for consumption or as an addition to the stock of fixed* CAPITAL—*not as* INPUTS *to be further*

transformed by some other production activity. The sum of all final goods and services is the GNP. *Final goods have proceeded through the various stages of production as far as they will ever go—that is, they have reached their "final" form in a physical sense. Distinguished from* INTERMEDIATE *goods, which must undergo further transformation before they reach their final form, and intermediate services, which contribute to a further production activity. A particular good or service may be either final or intermediate depending on the use to which reference is made. Thus, an orange is a final good if consumed directly and an intermediate good if it is used to make orange juice.*
Financial accounts
economic values determination and, 244, 246
foreign exchange premium and, 247
Financial analysis. *An analysis done using* MARKET PRICES. *Distinguished from* ECONOMIC ANALYSIS.
balance sheet (processing) preparation and, 192–95
economic analysis as complement to, 18
farm investment analysis and, 85–86
financial rate of return (processing) and, 209–12
financial ratios (processing) and, 202–09
income statement (processing) and, 195–97
incremental net benefit derivation and, 317–18
labor and land prices and, 72–73
market prices used in, 69
numeraire and, 244
"pattern" accounts and, 85–86
predicting future prices and, 75
processing industries overview and, 189–92
project objectives and, 46–47, 86–87
sensitivity analysis and, 363
sources-and-uses-of-funds statement (processing) and, 197–202
taxes and, 54
World Bank's Project Preparation Facility and, 441
Financial aspects of projects, 16–18
farm budget and, 129
financial rate of return as financial measure for, 209–12
project preparation and, 421–22
unit activity budget and, 146
Financial price. *See* MARKET PRICE
Financial price adjustment
export and import parity values and, 252, 269–71
indirectly traded items and, 265–69
nontraded items and, 253–65
traded goods and, 251–53
transfer payments and, 251
Financial prices, economic values determination and, 243, 244, 245
Financial rate of return. *The* INTERNAL RATE OF RETURN *calculated using financial values. The internal rate of return used in* FINANCIAL ANALYSIS. *See also* INTERNAL RATE OF RETURN; RATE OF RETURN
discount measures computation and, 357–58
farmer's own resources and, 129
as financial measure, 209–12
internal rate of return and, 331
project worth as, 128
sensitivity analysis and, 364
unit activity budget and, 147
Financial ratio. *One of a group of ratios, based on financial statements for an enterprise, that enable the project analyst to make a judgment about the efficiency of an enterprise, its return on key aggregates, and its* LIQUIDITY. *Often used in the analysis of* CREDITWORTHINESS. *In this book, the following financial ratios are discussed:* INVENTORY TURNOVER, OPERATING RATIO, RETURN ON SALES, RETURN ON EQUITY, RETURN ON ASSETS, CURRENT RATIO, DEBT-EQUITY RATIO, *and* DEBT SERVICE RATIO.
computation example, *204–05*
creditworthiness, 207–09
debt-equity, 208
efficiency, 203–06
income, 206–07
use of, 202
Financial results, project preparation and, 426–27
Financial statements
accounts and, 190–92
balance sheet, 190, 192–95
income, 190, *194*, 195–96
processing and, 189–90
sources-and-uses-of-funds, 190, 198–202
Financing plan. *In* PROJECT ANALYSIS, *a budget showing* CURRENT *costs for a project as opposed to the accounts cast in* CONSTANT *terms used for most of the analysis. Used to help a financing agency, such as the ministry of finance, plan for the amount of*

Financing plan (*continued*)
money needed year by year by the PROJECT. *Also, the plan for the various sources of finance to be used for a project (the national budget, foreign borrowing,* EQUITY *investment, and the like).*
First Livestock Development Project (Syria), 47
First-year return. *An analytical technique to determine the optimal time to begin a proposed* PROJECT. *In this technique, the incremental* NET BENEFIT *stream (cash flow) in the first year it is positive is divided by the total of the incremental net benefit* STREAM *(cash flow) in those years it is negative. The result expressed in percentage terms is the first-year return. The optimal time to begin the project is the earliest year for which the incremental net benefit stream for a project begun in that year has a first-year return exceeding the* OPPORTUNITY COST OF CAPITAL. *If the project begins earlier, for at least the first year it will fail to earn the opportunity cost of capital; if it begins later, a chance to earn the opportunity cost of capital on the initial* INVESTMENT *will have been passed by. Postponing a project can be advantageous only if the potential* BENEFIT *or* COST STREAM *will increase independently of when the project begins, an uncommon condition in agricultural projects but a common one in road projects where traffic will grow independently of the time the project begins. The first-year return technique makes an implicit assumption that once benefits begin they will be rising or constant.*
Fish catches, 15
Fish production, poor project analysis and drop in (Asia), 37
F.o b (free on board) prices. *The price of an export loaded in the ship or other conveyance that will carry it to foreign buyers. Compare with* C.I.F.
  export and import parity prices and, 78
  export and import parity values and, 269
  price distortions in traded items and, 253
Food and Agriculture Organization of the United Nations (FAO)
  computer use and, 408
  development bank cooperative programs of, 439–40
  price information and, 77
  project preparation reports and, 411
Foreign exchange. *See also* OFFICIAL EXCHANGE RATE
  domestic resource cost and, 398–400
  shadow price of (economic values determination), 244
Foreign exchange flow, 220–22
Foreign exchange premium. *The proportion by which the* OFFICIAL EXCHANGE RATE *overstates the* REAL *value of local currency or of* NONTRADED *goods and services relative to* TRADED *goods and services. Generally stated as a percentage. In* PROJECT ANALYSIS, *generally the ratio of domestic prices divided by* BORDER PRICES *Used to calculate the* SHADOW EXCHANGE RATE *and the* STANDARD CONVERSION FACTOR *for* ECONOMIC ANALYSIS, *usually based on a weighted average* TARIFF *calculation in which the premium equals the rate of the weighted average tariff. The shadow exchange rate is derived by multiplying 1 plus the foreign exchange premium stated in decimal form by the official exchange rate. In economic efficiency analysis, the standard conversion factor is the reciprocal of 1 plus the foreign exchange premium. The foreign exchange premium is a form of "price index" in which the "market basket" varies according to the use for which the index is intended. Specific conversion factors are similar indexes but are narrowly defined to include smaller market baskets and are applied to specific prices in the economic analysis of projects Mathematically, the standard conversion factor is the weighted average of all specific conversion factors; thus, the standard conversion factor and the shadow exchange rate incorporate more aggregated estimates of the effects of trade* DISTORTIONS *on the project than do specific conversion factors or disaggregated measures of applying shadow exchange rates. In project analysis, the foreign exchange premium focuses only on the trade component of international payments; in other uses, the foreign exchange premium may be defined to include other payments as well. See also* EFFICIENCY PRICE; INDIRECTLY TRADED; INDEX NUMBER
  conversion factor approach and, 248–49
  export and import parity values and, 270–71

indirectly traded items and, 266
price distortions in nontraded items and, 254
price distortions in traded items and, 252–53
relationships within equation for, 249–50
traded goods and, 247–48, 249–50
Forestry project (Tunisia), 386–88, *389*
Format. *See* Project format
Franchise tax (income statement preparation), 197
Free on board. *See* F.O.B. (FREE ON BOARD) PRICES
Fuel, predicting future prices and, 75
Full development. *With respect to a* PROJECT, *the period in the life of the project after the* INVESTMENT PERIOD *and the* DEVELOPMENT PERIOD *when a project is producing the maximum* OUTPUT *expected on a continuing basis.*
Funds flow analysis, *88*, 89, 90. *An analysis of the cash* INFLOW *and* OUTFLOW *in an enterprise. With reference to farms, an analysis to determine the farmer's* LIQUIDITY. *It is usually undertaken for the period of a loan repayment, is not discounted, uses* CURRENT *prices, treats* CAPITAL *by including cash purchases and sales of capital items, includes the cash portion of* OFF-FARM *income, and excludes* HOME-CONSUMED PRODUCTION. *The performance criterion is the cash available to the farm family as indicated by cash surplus or deficit. Also called "sources-and-uses-of-funds analysis." Distinguished from* FARM INCOME ANALYSIS *and* FARM INVESTMENT ANALYSIS. *Used in developing and evaluating the* FINANCING PLAN *for the farm or other enterprise.*
sources-and-uses-of-funds statement and, 198, 202
Funds from operations. *Revenue less cash* OPERATING EXPENSE *and* SELLING, GENERAL, AND ADMINISTRATIVE EXPENSE. *May also be determined as the sum of profit before* INTEREST *and* TAXES *plus* DEPRECIATION *and other noncash* OPERATING EXPENSES.
income statement and, 196, 197
sources-and-uses-of-funds statement and, 198

Garbage in, garbage out principle (GIGO), 9
GDP. *See* Gross domestic product (GDP); NATIONAL INCOME
Gearing. *See* LEVERAGE
Geographical location, project preparation and, 414–15
Ghana
market price determination example and, 71
Upper Region Agricultural Development Project in, 290, 291
GIGO. *See* Garbage in, garbage out principle (GIGO)
Gittinger, J. Price, 153, 158, 159, 163, 227
GNP. *See* Gross national product (GNP); NATIONAL INCOME
Goats, 175
Government, cash flow of, 217–20
Government agencies, 17
aggregation methods and, 289–91
debt repayment and, 87
financial assessment and, 86
project preparation and, 422–23, 426
Government expenditures and receipts, project effects and, 215–17
Government regulations, tradable but nontraded items and, 265
Grace period. *In credit transactions, a period during which a borrower need not repay* PRINCIPAL *and, sometimes,* INTEREST. *(Depending on the lending conditions, the borrower may or may not be required to pay interest, which may be* CAPITALIZED *during the grace period.) The grace period begins at the time the loan is extended and continues for a year (or other* ACCOUNTING PERIOD*) or more. Thus, a four-year grace period for a loan received at the end of project year 1 would mean that the grace period would be project years 2 through 5, and the first repayment of principal would be due at the end of project year 6.*
interest calculation (equal installment repayment) and, 153
interest determination and declining real burden of debt service and, 162
Grading, 73
project benefits and, 58
Grant, Eugene, 341
Grants, 132. *A payment made to an individual without expectation of goods or services in return. In* PROJECT ANALYSIS, *generally a payment by a government agency to an individual or firm to encourage a specific activity such as participating in a* PROJECT *or making an* INVESTMENT. *A grant is a* TRANSFER PAYMENT.
Gross benefit. *The incremental* OUTPUT *from a* PROJECT.
Gross domestic product (GDP), national income measures and, 292

Gross income, 196
Gross national product (GNP), national income measures and, 292
Gross profit, 196. *See also* Profit
Groundwater. *Water beneath the surface of the soil that supplies wells and springs.*
Guidelines for Project Evaluation (UNIDO 1972), 246, 248
Gunnerson, Charles G., 280
Guyana, Sea Defense Project in, 47–48

Harsh, Stephen B., 90
Health benefits, 280, 428
Heifers
  computational conventions and, 164–65
  culling rate and, 167
  defined, 163
  feed budget and, 185
  herd growth and, 180, 181
  stable herd determination and, 177, 179
Helmers, F. Leslie C. H., 347
Herd build-up. *See* HERD PROJECTION
Herd composition
  farm investment and, 123
  projected farm production and, 112, 115, 116
Herd productivity. *The ratio of animals sold from a livestock herd plus the increase in herd size during a year over the number of animals in the herd at the beginning of the year.*
Herd projection *A forecast year by year of the number and class of animals in a herd or other grouping. See also* Livestock
  adult mortality and, 166
  animal units and, 174–75
  calf mortality and, 166
  calving rate and, 166
  computational conventions and, 164–65
  culling rate and, 166–67
  feed budget and, 183–87
  herd growth and, 179–83
  herd productivity and, 162, 183, 185–86, *188*
  machine computation and, 183
  projected farm production and, 113–17
  purpose of, 163–64
  ratio of bulls to breeding cows and, 167–74
  stable herd determination and, 175–79
  technical coefficients and, 113, 115–16, 117, 165–74
  terminology and definitions for, 164
  worksheet for, 165, 166, *168–73*
High-yielding seed, 15, 365. *See also* YIELD
Hired labor, 416. *In agricultural* PROJECTS, *labor employed by a project or a farmer that is other than that of project participants or the farm family and that is paid a wage, perhaps an* IN-KIND PAYMENT. *Distinguished from* FAMILY LABOR.
  farm investment and, 123
  labor use analysis and, 103, 105–11
  valuing labor and, 261–62
Hogs, 113, 163, 185
Home-consumed production, 56. *Goods and services that are produced on a farm and are consumed by the farm family. The value of home-consumed production is included in both* FINANCIAL ANALYSIS *and* ECONOMIC ANALYSIS *in reaching the incremental* NET BENEFIT. *It is included among the* FINAL *goods and services that constitute* NATIONAL INCOME.
  debt service calculation and, 134
  farm budget and, 132
  small farms and, 90
Honduras, Agricultural Credit Project in, 150–51, *152*
House plot. *On a farm, the area immediately surrounding the family residence, it is often devoted to growing vegetables and similar crops, generally for home consumption.*
Housing
  farm budget calculations and, 132–33
  market price determination and, 73–74
  project benefits and, 59

Ilocos Irrigation Systems Improvement Project (Philippines), 319, 327, *328*, 331, 332, 343, 347, 401
Implementation
  delays and, 28–29, 36
  mutually exclusive projects and, 381–83
  project analysis and problems with, 29–35
  project cycle and, 24–25
  project preparation and, 418
  reestimation and, 27
  sensitivity analysis and delay in, 364, 369–71
Import parity prices, 78–80. *See also* TRADED
Import parity values, 252, 269–71, *276–77*

Imports
domestic resource cost and, 398
financial price adjustment (tradable but nontraded items) and, 263–65
foreign exchange premium and, 248
indirect (valuing), 265–66, 267
price distortions in traded items and, 251–53
of raw materials (market price as estimate of economic value example), 255–56
trade policy change and, 276, 277, 278
Import substitute, 252, 253. *An* OUTPUT of a PROJECT *that replaces goods or services that would have been imported without the project. See also* TRADED
Improved pasture. *Pasture in which the* YIELD *has been increased through a combination of measures such as planting higher-yielding grass species, planting legumes, or spreading lime. See* Pasture
Impute. *To determine a* PRICE *or* ECONOMIC VALUE *by some computation rather than by using an observed* MARKET PRICE. *To the extent possible, in* PROJECT ANALYSIS *it is desirable to avoid imputed prices. By taking the* POINT OF FIRST SALE *and using that as a base for the price used in a project analysis, the most serious weaknesses of imputed prices may be avoided. Such imputed prices as those for* INTERMEDIATE GOODS, *however, should be avoided whenever possible by defining the* PROJECT BOUNDARY *in such a way that it is at a point where a product can be priced or valued based closely on a* MARKET PRICE. *Thus, water in an irrigation project is not valued by means of an imputed price; rather, the boundary of the* PROJECT *is taken to be the* FARM GATE, *and the* BENEFIT *of the project is based on* FARM-GATE PRICES. *Water, then, is treated as an intermediate good within the project, and no price or value is imputed for it.*
Incentives, 89
assessment of, 86–87
cost recovery and, 225
financing and, 129, 134
rate of return to equity after taxes and, 213
Income. *The flow of goods and services accruing to an individual or a group of individuals.* NATIONAL INCOME *is the sum of the* FINAL *goods and services produced by an economy in a given time period. In accounting, income is revenues less expenses. Income may be stated before* TAX *or after tax; in the latter case it is often called "net income." In a private enterprise, income is profit. See also* Farm income; NATIONAL INCOME
farm budget and off-farm, 132, 260
farm investment and family, 123
labor, 138
operating before depreciation (sources-and-uses-of-funds statement), 198
operating and nonoperating (income statement), 196
project objectives and, 45–46
of rural poor, 28
time value of money (discounting dimension) and stream of, 309–13
undiscounted project worth measures and, 303–04
water charges and, 225
Income distribution. *The pattern of the division of total* NATIONAL INCOME *among the total population of a country.*
cost recovery and, 224
economic analysis and, 20, 21
economic values determination and, 245–46
national objectives and, 44–45
project impact on, 28
project preparation and, 413–14, 427
valuation and, 11
Income ratio, 191, 206–07
Income statement. *A financial report that summarizes the revenues and expenses of an enterprise during an* ACCOUNTING PERIOD. *It is thus a statement that shows the results of the operation of the enterprise during the period. Net* INCOME, *or profit, is what is left over after expenses incurred in production of the goods and services delivered have been deducted from the revenues earned on the sale of these goods and services. Thus, income (profit) = revenues − expenses.*
as basic financial statement, 190
example of, *194*
financial rate of return and, 211, 212
preparation of, 195–97
Income taxes. *See* Taxes, income
Incremental cash flow. *See* Incremental net benefit
Incremental net benefit. *See also* NET BENEFIT
aggregation, 287–89, 291, 296
debt service and, 134
derivation of, 315–19

farm budget and, 127–32, 133
farm family and, 123
financial rate of return calculation and, 210–12
internal rate of return and, 329, 332–35, 343
mutually exclusive projects and, 379
negative, 341, 349
net benefit increase and, 140
net benefit-investment ratio and, 347–49
net present worth and, 327
from operations (income statement), 196
unit activity budgets and, 142, 143, 146, 147
valuing land and, 256

Incremental operating expenditure, 98
incremental working capital and, 126, 127

Incremental residual value. *See also* RESIDUAL VALUE
farm budget and, 133
projected farm production and, 117–19, *121*

Incremental working capital. *See also* WORKING CAPITAL
accounting convention and, 98–99
farm budget and, 133
farm investment analysis and, 126–27
unit activity budget and, 143

Independent. PROJECTS *or project design options that can all be undertaken. Distinguished from* MUTUALLY EXCLUSIVE *projects or project design options, for which accepting one alternative necessarily excludes accepting another.*

Index number. *An index number is a ratio that measures the magnitude of one economic aggregate in relation to the magnitude of a comparable aggregate at a different point in time or place. The point of reference is called the "base." In time series, the "base period" is usually a particular year, perhaps one regarded as typical. The value of the aggregate in the base period is equated with 100, so that the index number for the year being measured (called the "current year") readily gives the percentage change between the base period and the current year. Index numbers can be used to show percentage changes in homogeneous aggregates such as total quantities of a single commodity or the total value of output or expenditure. Their main use, however, is to measure changes in the aggregates or averages of things that cannot be added together directly in a meaningful way. The method used to obtain more meaningful indicators of the average change is by weighting the percentage changes for each commodity according to its relative importance. In the case of a "quantity index," for example,* PRICES *are used as a measure of the relative importance of the change in quantities of different commodities. In the case of a "price index," quantities purchased are used as weights.*

India
Cashew Project in, 142–46, 157–58, 406
Drought Prone Areas Project in, 289
Farmers' Fertilizer Cooperative Project in, 400
Indus Basin Project in, 10
Maharashtra Irrigation Project in, 223, 227–28, 229–32, 397
shadow wage rate and, 262
Smallholder Dairy Improvement Project in, 57

Indirect benefit. *A form of* BENEFIT *that is* SECONDARY. *Changes in* INCOME *that accrue to sellers of project* INPUTS *(so-called* INDUCED-BY, *or "backward-linked," benefits) or to buyers of project* OUTPUTS *used as* INTERMEDIATE *goods (so-called* STEMMING-FROM *or "forward-linked," benefits). An alternative to the use of* SHADOW PRICES. In general more narrowly defined than secondary benefits. Used primarily in water resource programs in the United States.

Indirectly traded items. *Refers to a* NONTRADED *item that has a high import content. Examples include locally assembled tractors that partly use foreign components and construction that uses imported reinforcing rods. Valued by* DECOMPOSITION *(or breaking down) the* FACTORS OF PRODUCTION *used in the indirectly traded item into* TRADED *and nontraded components, which are then valued separately in the* ECONOMIC ANALYSIS *using either a* SHADOW EXCHANGE RATE *or a* CONVERSION FACTOR, *to allow for the* FOREIGN EXCHANGE PREMIUM. *Specific conversion factors are sometimes calculated for major indirectly traded items commonly used in* PROJECTS.
financial price adjustment and, 265–69
price distortion in traded items and, 253

Indirect tax. *See* TAX

Indirect transfer payment. *See* TRANSFER PAYMENT
Indonesia, Jatiluhur Irrigation Project in, 337, 365–71
Induced benefit. *A form of* MULTIPLIER *benefit that occurs through the Keynesian (or "respending") multiplier, which operates on consumption expenditures. Generally considered to double-count the* BENEFITS *of a* PROJECT *and thus is not commonly* used.
Induced-by benefit. *A form of* INDIRECT BENEFIT *that accrues to suppliers of project* INPUTS. *Includes the direct and indirect* VALUE ADDED *to* NATIONAL INCOME *generated by the* INVESTMENT *and* RECURRENT *expenditures of a* PROJECT. *Equivalent to using a* SHADOW PRICE *for a project input for which an adjustment is made for* OPPORTUNITY COST *in the estimates of direct and indirect value added. Sometimes estimated using specialized forms of input-output multipliers. See* STEMMING-FROM BENEFIT
Induced cost. An uncompensated adverse effect caused by the construction and operation of a PROJECT. *Used in U.S. government practice for computing the* BENEFIT-COST RATIO *at* MARKET PRICES.
Indus Basin Development Project (India and Pakistan), 10
Industrial projects, 255
  excess capacity and, 263
Inflation, 216. *An increase in the general* PRICE *level of an economy. Inflation occurs when the quantity of money in circulation rises relative to the quantity of goods and services offered. The result is "too much money chasing too few goods," and prices are bid up. At high rates of inflation, people tend to lose confidence in money, and the quantity of money in circulation increases relative to expenditures in* CURRENT *prices as people tend to hold (hoard) goods rather than money. Inflation is associated with a rise in gross national expenditure at current prices that is greater than the increase in the* REAL *supply of goods and services available. In* PROJECT ANALYSIS, *the customary analytical approach is to work in* CONSTANT *prices rather than current prices and to assume that inflation will affect the prices of all* COSTS *and* BENEFITS *equally, except for specified costs and benefits that are varied in comparison with the others so that the relative prices of these specified costs and benefits change. Using constant prices allows the analyst to avoid making risky estimates of future inflation rates and to simplify the analytical procedures.*
  contingency allowances and, 53, 54, 393–94, 395
  debt service and, 135–38
  declining real burden and, 158–62
  financial planning and, 87
  government cash flow and, 217–19
  measures of project worth (current prices) and, 400–01
  predicting future prices and, 76–77
Inflow. *All payments, goods, and services of value that are received or produced by an enterprise and that increase* NET BENEFIT. *In* FARM BUDGETS *intended for* FARM INVESTMENT ANALYSIS, *includes* HOME-CONSUMED PRODUCTION *and* OFF-FARM *income. Distinguished from* OUTFLOW.
Infrastructure
  Korean project for, 281–84
  poor project analysis and, 31–32
  project preparation and, 417, 418
In-kind payment. *A payment—in general, wages or a payment for cultivation rights—made in the form of goods or services rather than in money.*
Input. *A good (such as seed or fertilizer) or service (such as agricultural labor) used to produce an* OUTPUT *(such as crops or livestock).*
  commercial aspects of projects and, 16
  incremental working capital, 126–27
  investment, 119–23
  operating expenditure, 123–26
  predicting future prices and, 75
  project preparation and, 416, 424
Inspection, ranking projects by, 300–01
Institutional aspects of projects, 13–14
  project preparation and, 414, 417
Institutional assistance (project preparation), 437–43
Insurance, market value as estimate of economic value and, 256
Insurance scheme (herd), 116
Intangible. *In* PROJECT ANALYSIS, *refers to a* COST *or* BENEFIT *that, although having value, cannot realistically be assessed in actual or approximate* MONEY TERMS. *Intangible benefits include health, education, employment generation, electricity used for home lighting, and the value of domestic water supply. Intangible costs are often the absence of the related ben-*

Intangible (*continued*)
efit—disease, illiteracy, and so forth—but may also be such items as environmental degradation, inconvenience, and the like. Intangible benefits are sometimes valued as being at least equal to the estimated cost of the best alternative method of providing the same benefit. Thus, the benefit of supplying electricity for home lighting from a MULTIPURPOSE *river basin* PROJECT *may be taken to be the cost of providing the electricity by diesel generators. This method of* ALTERNATIVE COST VALUATION *should be used only in cases where the alternative actually would be undertaken in the absence of the project. The* TANGIBLE *cost of avoiding an intangible cost may be included in the cost of a project. Thus, the cost of avoiding downstream pollution from excessive fertilizer run-off may be included in the cost of a project as a means of dealing with the intangible cost of pollution. However, the nature of intangible costs and benefits is such that* REAL *value of the cost to those bearing it or of the benefit to project participants cannot be determined. When intangible costs or benefits are encountered in project analysis, the analyst should identify them and quantify them to the extent possible. Projects in which a substantial amount of the benefit is intangible may be evaluated using* COST EFFECTIVENESS ANALYSIS *See* EXTERNALITY

Integrated rural development project. *A* PROJECT *in which a conscious attempt is made not only to increase agricultural production in a rural area, but also to improve* INPUT *and* OUTPUT *marketing and the quality of rural life.*

Inter-American Development Bank, 411, 441

Intermediate. *With reference to goods and services, those goods and services that are used as an* INPUT *for further transformation by some other production activity—not for consumption or as an addition to the stock of fixed* CAPITAL. *Intermediate goods are an* OUTPUT *of one economic enterprise that have not yet reached the final form in which they will be used as an item of consumption or as an addition to the stock of fixed capital. Such goods proceed further through the production system and are used by other enterprises as an input. Distinguished from* FINAL *goods and services, which have reached their ultimate form for use in consumption, or as an addition to fixed capital. A particular good or service may be either final or intermediate depending on the use to which reference is made. Thus, an orange is an intermediate good if used to make orange juice and a final good if consumed directly.*

Intermediate goods, market price determination and pricing of, 71–72

Interest. *A payment for use of money, generally stated as a percentage of the amount* (PRINCIPAL) *borrowed The rate of interest is also used for* DISCOUNTING; *in that use it generally is referred to as the* DISCOUNT RATE *"Simple interest" is the interest paid in one period; compound interest is interest paid not only on the amount borrowed but on the interest earned in previous periods For methods of computation, see* COMPOUNDING FACTOR FOR 1 *and* DISCOUNT FACTOR.
benefit-cost ratio and, 345
capitalized equal installments and, 157–58
compounding of, 305–08
computing debt service and, 147–50
declining real burden of debt service and, 158, 161–62
economic analysis and, 19
equal installment repayment and, 153–56
foreign exchange flow and, 222
government cash flow and, 219, 220
income statement and, 196–97
internal rate of return and, 331, 335, 343
payments (sources-and-uses-of-funds statement), 199, 202
project costs and, 54–55
received (sources-and-uses-of-funds statement), 199
time value of money (discounting dimension) and, 305–08
unit activity budget and, 146

Internal rate of return, 210, 299, 343, 358, 401. *A discounted* MEASURE OF PROJECT WORTH. *The* DISCOUNT RATE *that just makes the* NET PRESENT WORTH *of the incremental* NET BENEFIT *stream, or incremental cash flow, equal zero. The maximum* INTEREST *that a* PROJECT *can pay for*

the resources used if the project is to recover its INVESTMENT *and* OPERATING EXPENSES *and still just break even. "The rate of return on capital outstanding per period while it is invested in the project" (Merrett and Sykes 1963, p. 38). For a formal mathematical definition, see the appendix to chapter 9. Often abbreviated* IRR. *When using the internal rate of return, the selection criterion is to accept all* INDEPENDENT *projects with an internal rate of return greater than the* CUT-OFF RATE, *which generally is the* OPPORTUNITY COST OF CAPITAL. *May give incorrect ranking among independent projects. Cannot be used directly for choosing among* MUTUALLY EXCLUSIVE *alternatives.*
comparison and ranking of, 358–61
computing, 332–39, 358
depreciation and, 351, 353
financial and economic rates of return and, 331
incremental net benefit derivation and, 317
interpolating value of, 336–39
mutually exclusive projects and, 375, 377–79, 383
point in time for calculation of, 341–43
possibility of more than one, 339–41
project selection and, 350–51
reinvestment of returns and, 339
replacement costs and, 395
switching value method and, 371
as useful measure of project worth, 329–32
International associations, price information and, 77–78
Internationally traded commodities, prices for, 77–78
Interpolation, 332. *Estimation of values (of a function) between two known values. "Linear interpolation" refers to a procedure of estimation that assumes that the function connecting two known values is a straight line. In this book, the most common—although not the only—use of interpolation is to estimate the* INTERNAL RATE OF RETURN *when it lies between two known values of the* NET PRESENT WORTH *obtained by* DISCOUNTING *the* NET BENEFIT *stream at two different* DISCOUNT RATES.
value of internal rate of return and, 336–39
Interviews (farmer), 92
Inventory. *Supplies of raw materials, finished goods, or goods in process that are held by an enterprise. Inventories sometimes include spare parts for machinery and equipment.*
creditworthiness ratios and turnover of, 208
efficiency ratios and turnover of, 203
increases and decreases in, 200–01
incremental net benefit before financing calculation and, 212
Inventory turnover ratio. *The cost of goods sold divided by the inventory. A* FINANCIAL RATIO *used to judge efficiency.*
Investment, 4, 5, 140, 246. *In* PROJECT ANALYSIS, *use of resources for a productive activity from which an* INCOME *is expected to flow at a future time. In* DISCOUNTED CASH FLOW ANALYSIS, *investment is defined mathematically as a negative incremental* NET BENEFIT, *or incremental cash flow, occurring for any* ACCOUNTING PERIOD. *See also* FARM INVESTMENT ANALYSIS
benefit-cost ratio and, 345
civil works and, 53
economic values determination and, 244
farm input analysis and, 119–23
internal rate of return and, 339
mutually exclusive projects and, 383
net benefit and, 210
on-farm (project preparation), 418
optimization (net benefit-investment ratio) of, 349–50
planning and, 6
project form and, 8
project implementation and, 25
project preparation and, 421
project purposes and, 390
return on (income ratios), 206
secondary costs and benefits and, 60, 61
sensitivity analysis and, 369
sources-and-uses-of-funds statement and, 198, 199
sunk costs and, 55
technical life of major, 355
undiscounted project worth method and, 300–04
unit activity approach to, 141, 143
Investment Centre (FAO), 411, 439, 440
Investment period. *With respect to a* PROJECT, *the period when the major project* INVESTMENTS *are undertaken. In agricultural projects, often three to five years.*

Ireson, W. Grant, 341
IRR. *See* INTERNAL RATE OF RETURN
Irrigation
  aggregation methods and projects for, 290
  cost recovery example and, 223–24
  cost recovery measure and, 227–28
  environmental impact and, 15–16
  excess capacity (industrial projects) and, 263
  joint cost allocation example and, 233–40
  new technologies and, 30
  poor project analysis and, 36–37
  project delays and, 29
  project preparation and, 415
  rate of return estimates and, 27
  rent recovery measure and, 229–32
  residual value and, 398
  small schemes vs. large schemes (selection method), 377–79
  water as an intermediate good and, 72
Irvin, George, 300

Jamaica Tall Coconut Project, 58–59
James, L. D., 240
Jatiluhur Irrigation Project
    Indonesian example and, 337, 365–71
    Javanese example and, 260, 261
Java
  harvesting practices of small farmers in, 259, 261
  Jatiluhur Irrigation Project in, 260, 261
Joint costs. *In a* PROJECT ANALYSIS, *project* COSTS *that serve more than one purpose in a* MULTIPURPOSE *project. An example is a dam that provides irrigation, power, and flood control. To allocate joint costs, the* SEPARABLE COSTS–REMAINING BENEFITS *method may be used.*
  general principles of allocation of, 233–34
  separable costs–remaining benefits method and allocation of, 234–40
Julius, DeAnne S., 280

Kalbermatten, John M., 280
Kay, Ronald D., 90
Kemubu Irrigation Project (Malaysia), 49, *50*, 256–57
Kenya
  Cotton Processing and Marketing Project in, 371–73
  South Nyanza Sugar Project in, 190–209, 217–22
  Third Agricultural Credit Project in, 140–41, 147–50
  Third Highway Loan Project in, 382–83
Korea, Rural Infrastructure Project in, 281–84

Labor. *See also* FAMILY LABOR; HIRED LABOR
  aggregation methods and, 294, 296
  farm investment analysis and, 90, 102–11
  income statement and, 196
  market price determination and, 72–73
  predicting future prices and rural, 76
  project costs and, 53
  unit activity budgets and, 141, 142, 143, 146
Labor value, financial price adjustment and, 258–63
Lagged annuity. Lagged annuity factor. *See* PRESENT WORTH OF A STREAM OF FUTURE INCOME
Land
  balance sheet and, 195
  farm budget and, 139–40
  market price determination and, 72
  project costs and, 53
  project preparation and, 415, 427
  tax on (farm budget), 133
  unit activity budgets and, 142, 143
Land improvement, 121
Land reform, 424
Land tenure. *See* Tenure
Land use
  farm budget and, 139
  farm investment analysis and, 99–101
  project preparation and, 415
Land value
  financial price adjustment and, 256–58
  residual value and, 119
Least-cost analysis. *See* COST EFFECTIVENESS ANALYSIS
Least-cost combination method, 280–81
Lee, R. R., 240
Leisure, 139
Level payment. *See* ANNUITY; EQUAL INSTALLMENTS
Leverage. *Use of borrowed* CAPITAL *to increase the return to* EQUITY. *Sometimes called "gearing."*
Liability. *A claim held by creditors against the* ASSETS *of an enterprise; in other words, the outstanding debts of the enterprise. "Current" liabilities are debts such as* ACCOUNTS PAYABLE,

SHORT-TERM *loans, current maturities due on term loans, and income* TAXES *that fall due within a year. "*LONG-TERM*" liabilities are debts such as* MEDIUM-TERM *and long-term loans and* SUPPLIERS' CREDITS *that become payable after one year from the date of the* BALANCE SHEET.
balance sheet preparation and, 192–93, 195
debt service coverage ratio and, 208
Life of project. *See* Project life
Lilongwe Development Program (Malawi), 356
Linear programming, 93. *A mathematical method of determining an optimal combination of* INPUTS *to maximize (or minimize) and objective in which the input variables involved are subject to constraint. In agricultural projects, occasionally used to optimize* CROPPING PATTERNS *to maximize* INCOME. *In practice requires a computer.*
Liquidity. *The readiness with which an* ASSET *can be converted into cash.*
Little, I. M. D., 20, 21, 246, 247, 249, 254, 267
Livestock. *See also* HERD PROJECTION
aggregation method and, 291
climate and poor project estimates for, 36
farm investment and, 121–23
farm investment analysis and, 92
incremental working capital for, 127
insurance scheme and, 116
labor use analysis and, 103–05
operating expenditure and, 123
projected farm production and, 112–17
project preparation and, 415, 418
residual value and, 119
unit activity budgets and, 141, 142
Livestock and Agricultural Development Project (Paraguay). *See* Paraguay Livestock and Agricultural Development Project
Livestock Development Project (Ecuador), 57
Loan receipts
computing debt service and, 147
debt service and, 134, 135
declining real burden of debt service and, 159, 161
farm budget and, 129, 132, 133
foreign exchange flow and, 222
government cash flow and, 219
unit activity budget calculations and, 146
Loans. *See also* Credit; DEBT SERVICE
balance sheet preparation and, 195
capitalized interest and, 157–58
computing debt service and, 147
direct transfer payments and, 50, 52
efficient resource use and, 86
equal installment payment calculations and, 153–56
government cash flow and, 219, 220
repayment of equal amounts of principal and, 150–53
simple interest calculations and, 150
social effects example (West Africa) and, 32
sources-and-uses-of-funds statement and, 199, 202
unit activity budget and, 146
Location, project preparation and, 414–15
Location of sale change, 57–58
Lome Convention, 438
Long-term. *Occurring over a relatively long period. Often taken to be more than one year. In economics, a period sufficiently long to depreciate fully and replace plant and equipment. In rural credit* PROJECTS, *a category of* MEDIUM-TERM *loans will be found. These often have a term of two to five years and are made to enable farmers to purchase equipment such as pumps, which have a life of five to ten years. The designation "long-term" loans, then, would be reserved for periods of more than ten years; such loans are often made to enable farmers to purchase land. Distinguished from* SHORT-TERM
Long-term liability. See LONG-TERM *and* LIABILITY
Loss avoidance, 58–59. *A loss that would have occurred without a* PROJECT *and that is avoided as a result of the project. A loss avoided is a* BENEFIT *attributable to the project.*
Loughlin, James C., 240
Lower Egyptian Drainage Project, 59

McDiarmid, Orville John, 259
McKean, Ronald N., 346
Maharashtra Irrigation Project (India)
cost recovery and, 223, 227–28
rent recovery and, 229–32
replacement costs and, 397
Malawi, Lilongwe Development Program in, 356
Malaysia, Kemubu Irrigation Project in, 49, *50*, 256–57

Managerial aspects of projects, 14–15
project preparation and, 422–24
Managers, 206
aggregation and remuneration of, 294–95
calf mortality rate decrease and, 166
competence of, 87
project evaluation and, 25–26
project implementation by, 25
project performance and, 33–34
rate of return and, 86
rent recovery and, 231
sensitivity analysis and, 369
steps in project analysis and, 37–40
Manual for Preparing and Appraising Project Dossiers (Commission of the European Communities 1980), 438
Manual on the Use of Consultants in Developing Countries (UNIDO 1972), 441, 442, 443
Maps (project preparation), 415
Marginal analysis. *Analysis of the change in one variable when a small change is made in another variable. An example of application is the* MARGINAL VALUE PRODUCT, *which is the amount* OUTPUT*—perhaps rice—is changed when a small change is made in an* INPUT*—perhaps fertilizer—all other inputs being held constant. Marginal analysis is an important concept underlying most* ECONOMIC ANALYSIS. *"On (or at) the margin" refers to a small change in the total of some input or output.*
Marginal cost. *The incremental total* COST *associated with producing one additional unit of* OUTPUT. *See* MARGINAL ANALYSIS
Marginal revenue product. *See* MARGINAL VALUE PRODUCT
Marginal value product, 75 *The value of additional* OUTPUT *generated by an additional unit of variable* INPUT. *Also called "marginal revenue product." If using one additional kilogram of elemental nitrogen results in an increase in rice production worth 12.30 currency units, then the marginal value product of a kilogram of elemental nitrogen is 12.30 currency units.*
prices as reflection of value and, 65–69
Marketing margin. *The difference between the* PRICE *a buyer pays for a good or service and the price at which he sells that good or service. In general, equal to the cost of providing the* MARKETING SERVICES *needed in a relatively competitive market. When the marketing entity can influence prices, the marketing margin may exceed the cost of the marketing services.*
Marketing services. *Services needed to make the* OUTPUT *of an enterprise (say, a farm) available to consumers in a form they prefer. Might include processing (or other transformation of form), storage, transport, financing, and risk bearing.*
Marketing structure, project preparation and, 423, 425–26
Marketing systems
imperfect, 60
poor project analysis and, 31, 32
Market price. *A* PRICE *at which a good or service is actually exchanged for another good or service* (as an IN-KIND PAYMENT) *or for money (in which case it is a financial price). A market price can refer to a transaction that occurs at any location, not necessarily a village or wholesale market. Distinguished from* SHADOW PRICE
Market prices
cost recovery and, 226
crossover discount rate example and, 388
economic analysis and, 19
economic values and, 243, 245, 246
as estimate of economic value, 254–56
financial analysis based on, 85
financial price adjustment (nontraded items) and, 253–56
finding of (brief overview), 69–70
first-sale price and farm-gate price and, 70–71
government cash flow account and, 217
indirectly traded items and, 265
joint cost allocation and, 233
managers and, 86
price distortions and, 251, 253–54
pricing intermediate goods and, 71–72
problems in determining, 72–74
project analysis and, 37, 40
project boundary price and, 74
tradable but untraded items and, 264
Materiality. *The quality of being large enough to affect decisions. A concept used in accounting.*
Measure of project worth. *A summary measure of the contribution a* PROJECT *will make to the objective of a participant in the project. In gen-*

eral, a measure of earning capability or of changes in INCOME, *including* NATIONAL *income for the economy as a whole. Undiscounted measures of project worth discussed in this book are* RANKING BY INSPECTION, PAYBACK PERIOD, PROCEEDS PER UNIT OF OUTLAY, AVERAGE ANNUAL PROCEEDS PER UNIT OF OUTLAY, *and* AVERAGE INCOME ON BOOK VALUE OF INVESTMENT. *Discounted measures of project worth discussed are* NET PRESENT WORTH (NPW *or* NPV), INTERNAL RATE OF RETURN (IRR), BENEFIT-COST RATIO (B/C RATIO), *and the* NET BENEFIT-INVESTMENT RATIO (N/K RATIO).
application of, 350–51
benefit-cost ratio and, 299, *342*, 343–46
computation guidelines for, 356–58
current prices and, 400–01
depreciation and, 351–55
discounted measures comparisons and, 358–61
discount measure considerations and, 299–300, 308–09, 313
discount rate choice and, 313–15
economic life of project and, 355–56, *357*
income streams and, 309–13
incremental net benefit (derivation of) and, 315–19
interest and, 305–08
internal rate of return and, 299, 329–43
mathematical formulation of, 361
mutually exclusive projects and, 373–93
net benefit-investment ratio and, 356–50
as net present worth, 128, 299, 319–33
project analysis and, 315
sensitivity analysis and, 363–71
time value of money dimension in discounting and, 304–15
undiscounted measures of, 300–04
Mechanization, benefits from, 58
Medium-term. *In rural credit projects, generally refers to loans extending two to five years. See* LONG-TERM; SHORT-TERM.
Merrett, A. J., 300, 341
Mexico, 10
Meyn, Klaus J., 163
Migration, project preparation and, 416–17, 427
Mirrlees, J. S., 20, 21, 246, 247, 249, 254, 267
Mishan, E. J., 59
Money terms. *The monetary* PRICES *of goods and services. Distinguished from* REAL *terms, which refer to the physical,* TANGIBLE *characteristics of goods and services.*
Monopolistic. *With reference to a market, a situation in which there is one (or a few) buyer or seller who therefore may be able to affect the* MARKET PRICE *materially. A monopolistic* MARKETING MARGIN *occurs when the margin between what a marketer pays for a good or service and what he sells it for is greater than would exist if there were many buyers and sellers in the market, all with good knowledge, and if a situation approaching perfect competition were to exist. A monopolistic market is a form of imperfect competition. Economists sometimes refer to a market where there are several—but still a relatively limited number—of buyers or sellers as oligopolistic.*
Morocco, Doukkala II Irrigation Project, 150
Mortality
of adult animals, 163, 166
of calves, 116, 163, 164, 165, 166, 176
Mortality rate. *With reference to livestock, the proportion of animals at the beginning of a time period that die during the period. Generally expressed as a percentage.*
Most probable outcome. *The value of a* MEASURE OF PROJECT WORTH *when the most probable value of every element in the project is used to calculate the measure. Compare with* SENSITIVITY ANALYSIS *and* RISK ANALYSIS
Multiple cropping. *Growing more than one crop on the same area in a year.*
Multiplier. *In macroeconomics, the proportionate increase in* NATIONAL INCOME *(in the form of consumption of* FINAL *goods and services) that occurs from each unit increase in new spending from some "autonomous" source such as private* INVESTMENT, *the government, or the outside world (through exports). The sum total of all additional consumption induced by the initial spending generally exceeds the amount of the initial spending itself. The quantitative measure of this additional consumption relative to the initial increase in investment spending is the multiplier. Many variants of the basic*

Multiplier (*continued*)
multiplier can be calculated Not generally used in PROJECT ANALYSIS *because of the difficulty of avoiding double counting of* BENEFITS. SHADOW PRICES *that include carefully traced indirect changes in* VALUE ADDED *include the multiplier effects while minimizing the danger of double counting Their use is therefore the approach preferred by many project analysts.*
Multipurpose projects. *Projects that serve several purposes and are characterized by* JOINT COSTS.
additional purposes in, 388–93
intangibles and, 281
joint cost allocation and, 233, 234
Mutually exclusive projects. *In* PROJECT ANALYSIS, *refers to* PROJECTS *or project design options that, by their very nature, are such that if one is chosen the other cannot be undertaken Examples include surface irrigation development, which rules out tubewell irrigation, or the same project begun in alternative years. Distinguished from* INDEPENDENT *projects or project design options.*
entirely different projects and, 377–79
instances of, 375–77
internal rate of return and, 375
multipurpose projects and, 388–93
net present worth and, 373–75
project scale and, 379–81
technology and, 383–88
timing of project and, 381–83

National development plan
project identification and, 22
social aspects of, 15
National income. *The total net earnings of labor and property employed in the production of goods and services in a nation during a period, usually a year. Broadly defined, it is commonly measured by the* GDP *(gross domestic product) or the* GNP *(gross national product).* GDP *is the value of the gross output of all goods and services produced in a nation less the value of* INTERMEDIATE *goods (those used to produce the goods or services).* GNP *is the same as* GDP, *except that it includes* INCOME *earned abroad and excludes income transferred out of the country by foreign owners.* GDP *can be measured in three ways, all of which are equivalent and give the same result: (1) the value of all expenditure on final goods and services produced (plus an allowance for* HOME-CONSUMED PRODUCTION*), less imports; (2) the sum of all payments to* FACTORS OF PRODUCTION *including an allowance for* CAPITAL *consumed by productive activities, and (for a* MARKET PRICE measure*) all indirect* TAXES *net of* SUBSIDIES; *and (3) the sum of the* VALUE ADDED *from every producing unit. Narrowly defined, national income excludes* DEPRECIATION *and indirect business taxes such as excise taxes and sales taxes. In this book, the broader definition is used. See also* INCOME
aggregation and measures of, 292, 293, 294, 296
economic analysis and, 19
trade policy changes and, 276–78
National objectives *See also* Objectives
costs and benefits and, 44
project identification and, 22
social aspects of projects and, 15
Negative. *With reference to* COSTS *or* BENEFITS, *refers to a value in a* COST *or* BENEFIT STREAM *that is opposite in sign to the sign normally associated with the stream. In the early years of a* PROJECT, *for example. the incremental* NET BENEFIT, *or cash flow, stream generally is negative, so that each of the first few entries is a negative benefit, or negative cash flow—which is, of course, a cost. In an* INCOME STATEMENT, *among the nonoperating income and expenses* INTEREST *received may be listed as a negative entry, in effect a negative cost—which is, of course, a benefit to the enterprise Such seeming anomalies or internally inconsistent terms arise because it is convenient to group kinds of entries in one place in a* PROJECT ANALYSIS *Thus, it is convenient to have an incremental net benefit stream as the basis for calculating the* INTERNAL RATE OF RETURN *even though there are costs included in what is called a benefit stream, and it is convenient to group both interest receipts and payments at one place in an income statement.*
Negative benefit, 318
Negative costs, 290
Net benefit In PROJECT ANALYSIS, *the amount remaining after all* OUTFLOWS *are subtracted from all* INFLOWS. *May be negative. The net cash flow. The*

incremental net benefit is the increase in net benefit with the PROJECT *as opposed to the case without the project. It is the incremental cash flow. In the early years of a project, the net incremental benefit usually is negative. The net incremental benefit is the basis for calculating* MEASURES OF PROJECT WORTH, *the most important of which are the discounted measures of* NET PRESENT WORTH, INTERNAL RATE OF RETURN, *and* NET BENEFIT-INVESTMENT RATIO *In reaching these measures (usually called* DISCOUNTED CASH FLOW ANALYSIS*),* COSTS *are entered in the year they are incurred, and* BENEFITS *are entered in the year they are realized. As a result, no* DEPRECIATION *is deducted before arriving at the incremental net benefit. In building project accounts for* FINANCIAL ANALYSIS, *the net benefit and incremental net benefit may be derived as (1) the net or incremental "net benefit before financing," in which case any financing transaction is excluded, and (2) as the net or incremental "net benefit after financing," in which case loans or other financial receipts are added to the net and incremental net benefits and* DEBT SERVICE *or other financial payments are subtracted from the net and incremental net benefits.* DISCOUNTING *the incremental net benefit before financing gives a measure of project worth of all resources engaged; discounting the incremental net benefit after financing gives a measure of project worth of the entity's own resources or* EQUITY. *See* BENEFIT; COST; Incremental net benefit; NET BENEFIT *entries.*

farm budget and increase in, 140–41
internal rate of return computation and, 332
rent recovery and, 229, 232
Net benefit after financing, 129, 133
debt service and, 134
financial rate of return and, 212
unit activity budget and, 147
Net benefit before financing, 127, 133
debt service and, 134
financial rate of return and, 210–11
unit activity budget and, 146
Net benefit increase. *A measure of additional* BENEFIT *received, generally applied to farmers. The* PRESENT WORTH *of the incremental* NET BENEFIT *after financing with the* PROJECT *divided by the present worth of the net benefit after financing without the project, expressed in percentage terms.*
Net benefit-investment ratio (N/K ratio), 209, 291, 299, 401. *A discounted* MEASURE OF PROJECT WORTH. *The* PRESENT WORTH *of the* NET BENEFITS *divided by the present worth of the* INVESTMENT. *A form of* BENEFIT-COST RATIO. *Calculated by taking the net benefits as the net present worth of the incremental net benefit (cash flow)* STREAM *in those years after the stream has turned positive and the investment as the present worth of the incremental net benefit (cash flow) stream in the early years of a project when it is negative. For a formal mathematical definition, see the appendix to chapter 9. Often abbreviated* N/K *ratio. When using the net benefit-investment ratio, the selection criterion is to accept all projects with a net benefit-investment ratio of 1 or greater when discounted at a suitable* DISCOUNT RATE, *most often the* OPPORTUNITY COST OF CAPITAL, *in order of ratio value until all available investment funds are exhausted. May be used to rank* INDEPENDENT *projects. Generally cannot be used directly to choose among* MUTUALLY EXCLUSIVE *alternatives.*

analysis of, 346–50
comparisons and ranking of, 358–61
computation of discounted measures and, 358
depreciation and, 351, 355
future prices and, 364
incremental net benefit derivation and, 317
mutually exclusive projects and, 373, 377–81
project selection and, 346–47, 349, 350, 351
replacement costs and, 395
residual value and, 397, 398
Net benefit-investment ratio of all resources engaged, 128
Net financing, 212. *Loan receipts less* DEBT SERVICE, *the payment of* INTEREST, *and repayment of* PRINCIPAL.
Net present value. *See* NET PRESENT WORTH
Net present worth, 140, 210, 299, 343, 401. *A discounted* MEASURE OF PROJECT WORTH. *The present worth of the incremental* NET BENEFIT, *or incremental cash flow,* STREAM *of a*

Net present worth (*continued*)
PROJECT *The present worth of the* BENEFITS *less the present worth of the* COSTS *of a project. For a formal mathematical definition, see the appendix to chapter 9. Often abbreviated* NPW *Also called the "net present value"* (NPV). *When using net present worth, the selection criterion is to accept all* INDEPENDENT *projects with a net present worth of zero or greater when discounted at a suitable* DISCOUNT RATE, *most often the* OPPORTUNITY COST OF CAPITAL. *Gives no ranking for order of implementation. When analyzing* MUTUALLY EXCLUSIVE *alternatives, accept the alternative with the greatest net present worth. Net present worth is the preferred selection criterion for mutually exclusive alternatives. See also* PRESENT WORTH
additional purposes and choice of, 389, 390–91, 393
aggregation method and, 291
comparisons and ranking of, 358–61
computing, 319–33, 358
depreciation and, 351, 355
future prices and, 364
incremental net benefit derivation and, 317
internal rate of return and, 331
mutually exclusive projects and, 373–75, 377, 382, 383
project selection and, 329, 350, 351
project worth as, 128
replacement costs and, 395
residual value and, 397, 398
switching value method and, 371–73
Netting-out, 345–46 In PROJECT ANALYSIS, *the process of subtracting* COSTS *from* BENEFITS *to obtain the* NET BENEFIT, *or cash flow. When using the net benefit as a basis for calculating a discounted cash flow* MEASURE OF PROJECT WORTH, *it does not make any difference where in the process netting out occurs so long as there is not any double counting. Thus, gross costs may be subtracted from gross benefits, the project costs subtracted from the sum of the net benefits realized on project farms, or any other suitable formulation. This is a great convenience because data are likely to reach the project analyst with costs subtracted from benefits, or netted out, in different patterns. In contrast, when using the* BENEFIT-COST RATIO *the netting out must be done in exactly the same pattern for all alternative projects. Otherwise, the values of the ratios cannot be compared directly with one another.*
Nigeria
Early-crop Maize Project in, 80–82, *83*, 271, *276–77*
Smallholder Oil Palm Project in, 288
Niswonger, C. Rollin, 190
N/K ratio. *See* NET BENEFIT-INVESTMENT RATIO
Nominal. *Stated as an amount of money Compare with* REAL
Noncash operating expenses, 196
Nontraded. *A project* INPUT *or* OUTPUT *that is not* TRADED *across the national boundaries of a particular country either because of its* COST *of production or because of restrictive trade practices. Common examples are unskilled labor and land In* PROJECT ANALYSIS, *refers to goods and services not traded by the country in which the project is located. In* ECONOMIC ANALYSIS *nontraded items are valued at their* MARGINAL VALUE PRODUCT *if they are* INTERMEDIATE *goods or services or according to the* WILLINGNESS TO PAY *criterion if they are* FINAL *goods or services. Distinguished from* TRADED.
Nontraded items
economic values determination and, 245
excess capacity and, 263
export and import parity values and, 269
financial price adjustment and, 253–65
foreign exchange premium and, 248, 250
labor value and, 258–63
land value and, 256–58
market prices and, 253–56
tradable but nontraded items and, 263–65
NPV. Net present value *See* NET PRESENT WORTH
NPW. *See* NET PRESENT WORTH
Numeraire. *The common measurement used as a unit of account. In* PROJECT ANALYSIS, *the unit that measures the objective being maximized.*
economic and financial analysis and, 244
Nutrition benefits, 280, 428

Objectives, 418. *See also* National objectives
cost recovery, 223–24

costs and benefits and, 45–46
financial analysis and, 86–87
plans and projects and, 6–7
project analysis and, 11
project preparation and social, 413
Off-farm. *In* PROJECT ANALYSIS *or* FARM INVESTMENT ANALYSIS, *not occurring on the farm that is the subject of the analysis, generally the farm of a* PROJECT *beneficiary. Off-farm* INCOME *is the income earned by a farm family from off-farm labor—employment somewhere other than its own farm. Off-farm work may include work on other farms.*
Official exchange rate. *The rate, established by the monetary authorities of a country, at which domestic currency may be exchanged for foreign currency. Where there are no currency controls, the official exchange rate is taken to be the market rate. The official exchange rate would always be used in* FINANCIAL ANALYSIS. *If more than one official exchange rate exists, then the rate or rates that apply should be used in financial analysis. See* FOREIGN EXCHANGE PREMIUM.
Olivares, Jose, 30
O&M. *See* OPERATION AND MAINTENANCE
OM&R. Operation, maintenance, and replacement. *See* OPERATION AND MAINTENANCE
OMVS. *Organisation pour la Mis en Valeur du Fleuve Senegal. See* Senegal River Development Program
On-farm. *In* PROJECT ANALYSIS *or* FARM INVESTMENT ANALYSIS, *occurring on the farm that is the subject of analysis, generally the farm of a* PROJECT *beneficiary. On-farm* INVESTMENT *is the project investment that occurs on the farms of project beneficiaries; an on-farm* PRODUCTION EXPENSE *is a project-related cost that occurs on the beneficiaries' farms.*
On the margin. *See* MARGINAL ANALYSIS
Operating entities, 191
Operating expenditure
accounting convention and, 98–99
cash (income statement), 195–96
cash (incremental net benefit before financing calculation), 212
contingency allowances and, 394
farm budget and, 133
farm inputs and, 123–26, 127
noncash (income statement), 196
unit activity budget and, 143
Operating expense. *The expense, other than financing, of carrying on the normal activities of an enterprise.* SELLING, GENERAL, AND ADMINISTRATIVE EXPENSES *are usually not included as an operating expense but are included as separate expenses in* INCOME *accounting.*
Operating income before depreciation. *See* FUNDS FROM OPERATIONS
Operating income (income statement), 196. *Revenue less expense. Operating profit.*
Profit before INTEREST *and* TAXES.
Operating margin. *The remainder after all expenses and* TAXES *are deducted from total sales.* NET INCOME. *Profit.*
Operating profit, 196. INCOME *(profit) before* INTEREST *and* TAXES. *See* INCOME
Operating ratio, 203–06. OPERATING EXPENSES *divided by revenue. A* FINANCIAL RATIO *used to judge efficiency.*
Operation and maintenance. *Refers to the routine* COSTS *of* PROJECT *implementation. Often abbreviated as* O&M. *Some agencies prefer operation, maintenance, and replacement, which is often abbreviated as* OM&R.
Operation and maintenance charge (cost recovery), 228
Operation and maintenance cost (separable costs–remaining benefits method), 234–35, 239, 240
Opportunity cost. *The* BENEFIT *forgone by using a scarce resource for one purpose instead of for its next best alternative use. For example, suppose a farmer produces both rice and maize but applies all his available fertilizer to rice. If instead he transferred some of the fertilizer to his maize, he would reduce the value of his rice production somewhat, but he might gain a much higher value of increased maize production. The value of his rice production forgone would be the opportunity cost of the fertilizer used for maize production. In this example, therefore, the opportunity cost is the* MARGINAL VALUE PRODUCT *of the fertilizer in its next best alternative use. In a perfectly competitive market where there are many buyers and sellers, all of whom have perfect information, the* MARKET PRICE *will equal the marginal value product of an item and thus market price, opportunity cost, and marginal value product will all be equal. In any enterprise,* NET BENEFIT, *or profit, will be maximized when the use of an*

Opportunity cost (*continued*)
INPUT *is adjusted to the point where its marginal value product is equal to its opportunity cost. In project evaluation, for the* FINANCIAL ANALYSIS *the opportunity cost of a purchased input is always its market price. In* ECONOMIC ANALYSIS, *however, the opportunity cost of a purchased input is always either its marginal value product in its best nonproject alternative use, if for* INTERMEDIATE *goods and services, or its* VALUE IN USE *(as measured by* WILLINGNESS TO PAY*), if it is a* FINAL *good or service. Since price is equal to marginal value product in a perfectly competitive market, in an economic analysis if an input is purchased in a reasonably competitive market the price is at least an initial estimate of the marginal value product of the input and, hence, of its opportunity cost. However, if because of market imperfections or other reasons the market price of an input does not closely approximate the marginal value product in its next best alternative nonproject use, the marginal value product is estimated directly, and that estimate becomes the* SHADOW PRICE *of the item. The concept of opportunity cost is a cornerstone of* PROJECT ANALYSIS *and is the central concept underlying valuation of project inputs. See also* OPPORTUNITY COST OF CAPITAL
economic values and, 243, 245
family labor and, 139
farm-gate price calculation of market prices and, 71
foreign exchange premium and, 250
operating expenditure (family labor or land) and, 126
prices as reflection of value and, 68–69
secondary costs and benefits analysis and, 60
tradable but nontraded items and, 264
unit activity budget problems and, 142, 143, 146
valuing labor and, 258, 260, 262
Opportunity cost of capital. *The* OPPORTUNITY COST *of using* INVESTMENT *resources in a* PROJECT *rather than in their next best alternative use; usually expressed in the form of an* INTEREST *rate. The reduction in nonproject* BENEFITS *in relation to project objectives that is a result of using* CAPITAL *in the project. In practice, usually a weighted average calculation of the* COST *of securing project capital from various sources In* FINANCIAL ANALYSIS, *the weighted average cost to the firm or farm of* EQUITY *capital and of borrowed capital from likely sources. In* ECONOMIC ANALYSIS, *usually the weighted average cost of capital to the economy as a whole, but sometimes the weighted average cost of capital to the public sector. The rate at which benefits and costs are discounted in calculating the* NET PRESENT WORTH, *the* NET BENEFIT-INVESTMENT RATIO, *or the* BENEFIT-COST RATIO *The* CUT-OFF RATE *for* PROJECT ANALYSIS, *and hence the minimum acceptable* INTERNAL RATE OF RETURN. *Several methods exist for formulating and for calculating the economic opportunity cost of capital. Difficulty in calculating the opportunity cost of capital is a primary reason for widespread use of the internal rate of return as a* MEASURE OF PROJECT WORTH.
cut-off rate and, 314
discount measures and, 314, 333, 346, 359
internal rate of return and, 332
mutually exclusive projects and, 382, 383
net benefit-investment ratio and, 346
net present worth method and, 382, 383
Tunisian forestry project example and, 387
Optimization of project investment, 349
Organizational aspects of projects, 14
farmers and, 31
project preparation and, 422–24
Outflow. *All payments that are made, or goods and services of value that are consumed or transferred, to other entities and that decrease* NET BENEFIT *Distinguished from* INFLOW.
Output. *A good or service produced by an activity. In* PROJECT ANALYSIS, *the product of the* PROJECT.
aggregation and, 293
commercial aspects of projects and, 16
loss avoidance and, 59
market price as estimate of economic value and, 255
predicting future prices and, 75
with and without comparisons and, 47–50

Overrun. *Exceeding the* COSTS *estimated or budgeted.*
Owners' equity. *See* Equity, owners'
Oxen. *See* Work oxen

Pakistan
  Canal Lining Project in, 48–49
  Indus Basin Development Project in, 10
  tradable but nontraded items example and, 265
Paraguay Livestock and Agricultural Development Project, 143, 159
  construction and, 119
  equal installment repayment example and, 153–56
  farm budget preparation and, 127–40
  farm-gate prices and, *118*
  farm investment analysis example and, 94
  herd projection and, 116
  herd projection example and, 163–87
  incremental working capital and, 123–26
  investment and, 119–23
  labor use example and, 102–11
  land use example and, 99–101
  operating expenditure and, 123–26
  valuation and, 117
Parity. *In* PROJECT ANALYSIS, *a parity* PRICE *or parity* ECONOMIC VALUE *is the price or value of a project* INPUT *that is based on a* BORDER PRICE *adjusted for expenses between the border and the* PROJECT BOUNDARY.
Partial analysis. *An analysis that assumes that only certain elements analyzed will change while all others remain the same. Formally,* ECONOMIC ANALYSIS *is a partial analysis because only the elements of the* PROJECT *are assumed to change while the overall economic setting remains unchanged. When this formal assumption must be relaxed (for instance, when a project will itself have an effect on external financial* PRICES, *or* ECONOMIC VALUES), *then conceptual problems arise about the validity of the analysis.*
Partial budget. *A budget that addresses itself to only part of an enterprise. Compares the* MARGINAL COST *(including* OPPORTUNITY COST*) of an activity within an enterprise with the marginal increase in* BENEFIT *that the new activity will bring. Distinguished from* WHOLE FARM BUDGET. *See also* UNIT ACTIVITY BUDGET
  techniques for, 91, 141
Partial payment factor. *See* CAPITAL RECOVERY FACTOR
Participants. *See* Project participants
Pasture, 115
  carrying capacity and, 164, 174, 175
  feed budget and, 185
  improving, 165
  labor use analysis and, 102
  operating expenditure and, 123–26
  projected farm production and, 112, *113*
  stable herd determination and, 178
Pattern farm plan. *A model or prototype of a "typical"* FARM BUDGET *that forms a basis for aggregating* COSTS *and* BENEFITS *in an agricultural* PROJECT *and for making judgments about such other aspects of the project as the incentive effect for farmers, feasibility, rate of acceptance, and* LIQUIDITY.
Pattern farms. *See also* Farms
  aggregation methods and, 287–89
  farm budgets and, 90, 93–94
  farm investment analysis and, 85–86, 89
Payback period, 302. *An undiscounted* MEASURE OF PROJECT WORTH. *The time from the beginning of a* PROJECT *until the net (undiscounted) value of the incremental production* STREAM *totals the amount of the (undiscounted)* INVESTMENT *of* CAPITAL.
Payment
  aggregation and labor, 294, 296
  labor and, 262–63
Performance audits, 26–27, 29–30
Perrins, R. E. G., 190
Personnel, 33
Phasing of project (project preparation), 419–20
Philippines
  Crop Response to Nitrogen Fertilizer Project in, 65–69
  Ilocos Irrigation Systems Improvement Project in, 319, 327, *328*, 331, 332, 343, 347, 401
Physical contingencies, 53–54, 395. *See also* CONTINGENCY ALLOWANCES
Physical goods costs, 52–53
Pigs, 113, 163, 185
Planning, 22, 23
  economic growth and, 6–7
  financial analysis and, 87
  project format and, 8
  water resources booklet for, 345
Point of first sale, 70–71. *The location where the first sale transaction takes place for a product. If the point of first sale is in a relatively competitive*

Point of first sale (*continued*
market, the PRICE *may be a good estimate of* ECONOMIC VALUE. *By using a price derived from the point of first sale, the analyst avoids using an* IMPUTED *value*
Policy
changes in trade, 271–78
project success and price, 34–35
Political environment, projects and, 11
Pollution, 16
Population, project preparation and, 416–17
Population projects, 280
Pouliquen, Louis Y., 371
Poultry, 113, 163, 185
Poverty, project preparation and, 413–14
Power benefit, 234
Powers, Terry A., 183
Preparation. *See* Project preparation
Present worth. *(1) The value at present of an amount to be received or paid at some time in the future. Determined by multiplying the future value by the* DISCOUNT FACTOR, *which is* $1 \div (1 + i)^n$ *where* i = *the* DISCOUNT (INTEREST) RATE *and* n = *the number of years. In practice, the discount factor is obtained from a set of compounding and discounting tables. (2) The sum of the present worths of a series of future values. See also* NET PRESENT WORTH
benefit-cost ratio and, 345
of capital cost (cost recovery index) 226
discounting, 308–09, 356
domestic resource cost and, 400
future income stream and, 309–13
net benefit-investment ratio and, 347–49
residual value and, 398
separable costs–remaining benefits method and, 235–36, 237
Present worth of an annuity factor *How much 1 received or paid annually is worth today. Also called the "present worth of 1 per annum" and the "discount factor for a stream of income." The expression* $[(1 + i)^n - 1] \div [i(1 + i)^n]$ *where* i = *the rate of* INTEREST *and* n = *the number of years. The reciprocal of the* CAPITAL RECOVERY FACTOR. *Generally obtained from a set of compounding and discounting tables. This factor enables determination of the* PRESENT WORTH *of a* CONSTANT *amount received or paid each year for some length of time in the future. Its use is direct and simple if it is used for a constant* STREAM *of money that begins in the first year and lasts to some future year, say 11, of a* PROJECT. *It may also be used to determine the present worth today of a constant stream of money that begins some time other than the first year, say in the 7th year of a project and continuing through the 15th year, although this takes some additional manipulation. See appendix B, and the subheading "Present worth of a stream of future income" in chapter 9, see also* TIME VALUE OF MONEY
Present worth factor. *See* DISCOUNT FACTOR
Present worth of 1. *See* DISCOUNT FACTOR
Present worth of 1 per annum. *See* PRESENT WORTH OF AN ANNUITY FACTOR
Present worth of a stream of future income. *The* PRESENT WORTH *(at time* t_0*) of a* STREAM *of* INCOME *commencing sometime in the future (that is other than at time* t_1*). When the stream of future income consists of the same amount paid or received each* ACCOUNTING PERIOD, *the present worth may be determined by subtracting the* PRESENT WORTH OF AN ANNUITY FACTOR, *for the number of years before the stream begins for the appropriate* INTEREST *rate, from the present worth of an annuity factor for the last year of the stream and by multiplying the resulting factor by the amount paid or received each accounting period. The future income stream is sometimes called a "lagged annuity," and the factor derived from the present worth of an annuity factor may be called the "lagged annuity factor."*
Prest, A. R., 59, 300
Price. *The amount (usually of money) that must be exchanged for a good or a service. In general in this book, price refers to a* MARKET PRICE, *or a financial price discussed as part of* FINANCIAL ANALYSIS, *as distinguished from an* ECONOMIC VALUE, *which is used for amounts discussed in connection with* ECONOMIC ANALYSIS. *See* ECONOMIC VALUE, MARKET PRICE; PARITY; Prices; SHADOW PRICE
Price contingencies, 53–54, 393–94, 395. *See also* CONTINGENCY ALLOWANCES
Price index. *See* INDEX NUMBER
Price Prospects for Major Primary Commodities (World Bank 1982), 76, 77, 217

Prices
contingency allowances and, 393–94, 395
declining real burden and, 158–59
efficiency ratio and, 206
electricity, 267
finding market, 69–74
implementation of project and changes in, 24
information on international, 77–78
for internationally traded commodities, 77–78
predicting future, 74–77
project analysis success and, 34–35
project format limitations and, 10, 11
as reflection of value, 65–69
sensitivity analysis and, 364
valuing land and, 257
water charges (cost recovery) and, 223–24, 225
Price system. *The system by which the amounts and qualities of goods and services are determined (and, hence, resources to produce them allocated) by the* PRICE *that consumers are willing to pay. In a price system in which markets are permitted to work without outside intervention, the price system will tend toward an optimal allocation of resources and of production of goods and services: if there is a shortage of an item the price will rise, and new resources will be applied to its production, until a new equilibrium is achieved in which no other combination of goods and services produced or allocation of resources could produce greater satisfaction. In practice, no price system achieves this ideal. In all markets there are frictions caused by lags in response. Certain public services that are not easy to sell through the market cannot readily be incorporated in the price system. For historical reasons, some individuals or groups may have a* (MONOPOLISTIC) *control over* ASSETS *that permits them to manipulate the price system to their own advantage. Finally, a consumer's ability to buy and sell depends on his* INCOME, *which may not reflect the society's view about the consumption desirable for that person. For reasons such as these, all societies direct the price system to a greater or lesser degree so that it can better serve the particular society's purpose; such efforts constitute the substance of price policy. See also* DISTORTION; EFFICIENCY PRICE; MARKET PRICE; SHADOW PRICE
Principal. *The amount of a loan.*
capitalized interest and, 157–58
computing debt service and, 147
declining real burden of debt service and, 158, 161–62
equal installment repayment and, 156
foreign exchange flow and, 222
government cash flow and, 219
repayment, 202
repayment of equal amounts and, 150–53
Private enterprises, 17, 18, 21
debt financing and, 207
debt repayment and, 87
financial assessment and, 86
objectives and, 44
"Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning" (U.S. Government 1979), 345
Proceeds per unit of outlay, 302. *An undiscounted* MEASURE OF PROJECT WORTH. *The total net (undiscounted) value of incremental production divided by the total (undiscounted) amount of the* INVESTMENT.
Processing industries
aggregation and, 289
balance sheet statement and, 190, 192–95
creditworthiness ratios and, 207–09
efficiency ratios and, 203–06
financial analysis overview of, 189–92
financial rate of return measure and, 209–12
financial ratios and, 202–09
income ratios and, 206–07
income statement and, 190, *194*, 195–96
project benefits and, 58
project preparation and, 419, 426
sources-and-uses-of-funds statement and, 197–202
Procurement
equipment and, 16
project preparation and, 422
Procurement procedures, 16
delays in, 33
Producer prices, importance of, 34–35
Production, 4, 5, 206
aggregation method and farm, 291
crops and pasture and, 112
discounting assumptions and, 99
farm budget and, 132
incremental residual value and, 117–19, *121*
livestock and, 112–17, 183, 185–86
project benefits and, 56–57

Production (*continued*)
projected farm (farm investment analysis), 111–19
project preparation and, 425
rent recovery computation and, 229, 231
unit activity budget and, 143
valuation and, 117, *120*
with and without comparisons and, 47–49
Production expense. *A* COST, *incurred to produce project* OUTPUT, *that is recovered as soon as the output is sold or consumed. Variable cost. Examples include wages and fertilizer.*
Profit. *See also* INCOME
before taxes (income statement), 197
government cost flow and, 219
gross, 195
operating (income statement), 196
Program. *An ongoing development effort or plan. Distinguished from a* PROJECT, *which has a specific objective, activity, beginning, and end. May include various projects at various times as its constituent units.*
Program analysis, 4–5
Programming model, 10
Project. *In this book, generally refers to an* INVESTMENT *activity upon which resources—*COSTS*—are expended to create capital* ASSETS *that will produce* BENEFITS *over an extended period of time and which logically lends itself to planning, financing, and implementing as a unit. A specific activity, with specific starting point and specific ending point, intended to accomplish a specific objective. The smallest operational element prepared and implemented as a separate entity in a national plan or* PROGRAM. *Generally unique in that it is not a segment of an ongoing program, although it may be a "time slice"—a portion lasting several years—of a* LONG-TERM *program. May produce* BENEFITS *that can be valued in* MONEY TERMS *or benefits that are* INTANGIBLE. *See* Projects
Project analysis. *An analytical system that compares* COSTS *with* BENEFITS *to determine if a proposed* PROJECT, *given the alternatives, will advance the objective of the entity from whose standpoint the analysis is being undertaken sufficiently to justify undertaking the project.*
accuracy of, 26–29
analytical techniques and, 10–12
calculators and, 401–08
computer use and, 408
contingency allowances and, 394–95
design and implementation problems with, 29–35
discounting convention for, 315
discount measure selection and, 359
economic aspects of, 18–21
farm budget aggregation and, 289
financial aspects of, 16–18
government receipts and expenditures and, 215–17
incremental net benefit and, 318
institutional aspects of, 13–14
internal rate of return and, 341
managerial aspects of, 14–15
organizational aspects of, 14
partial, 10
planning and, 6–7
problems with poor, 35–37
programs and, 4–5
project format and, 8, 9
project sequence (cycle) and, 22–24
social aspects of, 15–16
switching value method and, 371
technical aspects of, 12–13
trade policy changes and, 271–78
unit activity budget approach to, 141
Project boundary. *The extent of the activities included within* PROJECT *accounts. Derives from the concept of the physical boundaries of a project, but is extended to allow for projects that do not have fixed geographical boundaries but rather may have a combination of participants in various geographic locations.*
Project boundary price
economic import parity value and, 270
export and import parity prices and, 78
market price determination and, 74
Project cycle. *The sequence of analytical phases through which a* PROJECT *passes. In this book taken to be: identification, preparation and analysis,* APPRAISAL, *implementation, and evaluation. (See Baum 1978.) Many variations of this particular division of the project cycle have been proposed. See* PROJECTS, sequence (cycle) of
Project delays
in implementation, 28–29, 36
procurement problems and, 33
sensitivity analysis and, 364, 369–71
Project design, problems with, 29–35
Project format, 5. *An analytical framework, for a proposed* INVESTMENT, *in which the* COST *and*

BENEFIT *accounts are prepared in the form of a* PROJECT.
advantages of, 7–9
limitations of, 9–12
Project implementation. *See* Implementation
Project life
accuracy of analysis and, 27
discount factors and, 355–56, *357*
farm investment analysis and, 90
implementation of projects and, 25
investment funds movement (sources-and-uses-of-funds statement) and, 198
separable costs–remaining benefits method and, 235
Project model (aggregation example), 291–96
Project objectives. *See* Objectives
Project participants, 5. *See also* Farmers; Government agencies; Private enterprises; Public enterprises
aggregation methods and, 289
farm investment analysis and, 90
financial aspects of projects and, 17, 86
financial planning and, 87
financing of projects and, 129
project preparation and, 424
Project preparation
design and analysis of, 12–21
guidelines for report on, 411–28
implementation delays and, 29
importance of, 3
institutional assistance for, 437–43
poor project analysis and, 35–36
sequence of projects and, 22–24
steps in project analysis and, 37
Projects. *See also* Multipurpose projects; Mutually exclusive projects; Single purpose projects
defined, 4–6
expansion and, 191
identifying, 21–22
market price as estimate of economic value and, 255
phasing of, 419–20
ranking of, 300–04, 329, 346, 346–47, 349, 350–51, *352–53*
selecting among alternative (discounted measures), 350–51
sequence (cycle) of, 21–26
small vs. large, 377
testing, 9–10
water development (joint cost allocation), 233
Project selection. *See also* Ranking
alternative, 350–51
costs and returns values and, 6
Public enterprises, 17, 198
debt-equity ratio and, 208
debt repayment and, 87
financial assessment and, 86
income ratios and, 207
objectives and, 44
Purchases (herd), 112, *114*, 116, 117
accounting convention and, 164, 165
farm investment and, 123
feed budget and, 187
herd growth and, 183
herd projection and, 163

Quality
improvements, 57, 428
prices and, 73
Questionnaire (farm investment analysis), 92–93
Quotas, 263, 276, 277, 278. *In reference to foreign trade policy, a quota is a limitation on the quantity of an item that may be imported*

Rahad Irrigation Project (Sudan), 74
export parity price example and, 78–80, 271, *272–75*
Rajasthan Smallholder Dairy Improvement Project (India), 57
Ranking, *352–53*
application of, 350–51
benefit-cost ratio and, 346
comparisons and criteria for, 358–61
by inspection, 300–01
net benefit-investment ratio and, 346–47, 349
net present worth and, 329
undiscounted project worth measures and, 301–04
Ranking by inspection. *An undiscounted* MEASURE OF PROJECT WORTH *that simply consists of examining the* INVESTMENT *cost of a* PROJECT *and the shape of the net value of incremental production* STREAM. *In general, there are two instances when ranking by inspection may be used: (1) when, with the same investment, two projects produce the same net value of incremental production for a period but one continues to earn longer than the other; and (2) when, for the same investment, the total net value of incremental production of two projects is the same but one project has more of the flow coming earlier in the time sequence.*
Rate of acceptance. *The rate at which farmers adopt new techniques or technology.*

Rate of return. *Remuneration to* INVESTMENT *stated as a proportion or percentage. Often the* INTERNAL RATE OF RETURN. *The* FINANCIAL RATE OF RETURN *is the internal rate of return based on* MARKET PRICES; *the* ECONOMIC RATE OF RETURN *is the internal rate of return based on* ECONOMIC VALUES. *See also* ECONOMIC RATE OF RETURN; FINANCIAL RATE OF RETURN; INTERNAL RATE OF RETURN
discount measures and, 357–58
efficient resource use and, 86
financial rate of return and, 210
income ratios and, 206
project analysis accuracy and, 27–28
residual value and, 397, 398
sunk costs and, 55
Ratio analysis *See* FINANCIAL RATIO
Real. *Reflects the physical, not* NOMINAL *or relative, quantities of goods or amounts of services. A financial* PRICE *or* ECONOMIC VALUE *quoted in real terms refers to the same physical quantity of goods or actual amount of services whenever it appears in a series. A financial* PRICE *or* ECONOMIC VALUE *quoted in* MONEY *(or nominal)* TERMS *refers to the monetary prices of goods and services and, because of the effect of general price* INFLATION, *may vary at different times even though it refers to the same quantity of goods and services.*
Real burden of debt service. *The proportionate* DEBT SERVICE *burden relative to all other* PRICES *paid by the borrower. In* FARM INCOME ANALYSIS, *the* FARM BUDGET *most often is calculated assuming that debt service will be* CONSTANT *in* REAL *terms. Yet in most countries lending terms to farmers call for repayment in* NOMINAL *or* MONEY TERMS. INTEREST *is stated at a given rate and the nominal amount of* PRINCIPAL *repayment is agreed upon. Under conditions of* INFLATION *that would reduce the real value of money over time, the result would be that farmers would have a declining real burden of debt service over the life of the loan To avoid this outcome, a loan may be indexed to some appropriate price index so that the real burden remains the same during the life of the loan.*
declining assumptions and, 158–62
Reconciliation accounts, 197
Recurrent. *Occurring repeatedly. Recurrent* COSTS *of a* PROJECT *are those which occur repeatedly as the project is implemented. Usually refers to costs borne by the government budget. Some governments have separate recurrent and* CAPITAL *budgets from which project costs are financed.*
Regionality, social aspects of projects and, 15
Relative prices. *See also* INFLATION
declining real burden and, 158
predicting future prices and, 75–76
Rent *A fixed periodic payment made by a user to an owner for the possession and use of property. Compare with* ECONOMIC RENT
unit activity budget calculations and, 143
valuing land and, 257
Rental value of farm house
farm budget calculations and, 132–33
market price determination and, 74
Rent recovery (measuring), 228–32
Rent recovery index *The proportion of the* ECONOMIC RENT *created by a* PROJECT *that accrues to project beneficiaries and is recovered from them. In an irrigation project, equals [(incremental revenue from water sales + incremental* BENEFIT TAXES*) − incremental economic rent accruing to project beneficiaries], stated in percentage terms. Calculated in* CONSTANT, MARKET PRICES, *generally for a year after the project has reached* FULL DEVELOPMENT
Repayment
computing debt service and, 147
of equal amounts of principal, 150–53
government cash flow (principal) and, 219, 220
of loans (sources-and-uses-of-funds statement), 199, 202
money terms and, 158
project preparation and, 423
Replacement costs. *See* Costs, replacement
Resale value. *See* RESIDUAL VALUE
Research, 31
project preparation and, 424
Reservation price *The minimum* PRICE *at which an individual is willing to offer a good or service. Often applied to labor, it is the lowest wage at which an individual is willing to offer his or her services.*
for leisure, 139
Reserves (retained earnings), 195
Residual asset. *See* RESIDUAL VALUE
Residual value. *The value of an* ASSET *remaining unused at the end of a* PROJECT. *Also called "terminal value." The asset itself may be called a "re-*

sidual asset." In PROJECT ANALYSIS, *the residual value is generally added to the* BENEFIT STREAM *in the last year of the project. It is often taken to be the "resale value" of an asset that is used and then put up for sale. "Salvage value" is a form of residual value that refers to an asset that at the end of the project has value only as scrap.* WORKING CAPITAL *is treated as a residual value credited to the project in the final year of the analysis.*
projected farm production and, 117–19, *121*
resale value of fixed assets as, 196
Resources
aggregation and flow of, 293
cost of domestic, 398–400
efficient use of (judgment), 86
farm budget calculations and, 128
farmer's own (use of), 129, 140
financial rate of return to all, 209, 210–12
labor use and, 102–11
land use and, 99–101
project preparation and, 415
real costs and benefits of (tradable but nontraded items), 263
unit activity budgets and, 142
Retained earnings, 195. *In U.S. accounting terminology, the portion of net* INCOME, *or profit, that is kept and reinvested within an enterprise rather than distributed as* DIVIDENDS *to shareholders. In British accounting terminology, called "reserves."*
Return on assets. OPERATING INCOME *divided by* ASSETS. *A* FINANCIAL RATIO *that is used to judge return to critical aggregates.*
Return of capital. *The return to the investor of part or all of the initial* INVESTMENT *of* CAPITAL *in a* PROJECT. *The incremental* NET BENEFIT, *or incremental cash flow, is an undifferentiated* STREAM *of amounts consisting of the return of capital and the* RETURN TO CAPITAL.
Return to capital. *The* RATE OF RETURN *received by the investor on* CAPITAL *engaged in a* PROJECT. *The incremental* NET BENEFIT, *or incremental cash flow, is an undifferentiated* STREAM *of values consisting of the return to capital and the* RETURN OF CAPITAL. *The* INTERNAL RATE OF RETURN *is a measure of the return to capital. When the internal rate of return is zero, all capital is returned by the cash flow, but there is no return to capital.*
farm income analysis and, 89
Return on equity. *(1) the* INTERNAL RATE OF RETURN *of the incremental* NET BENEFIT *after financing. Used as a* MEASURE OF PROJECT WORTH. *(2) Net* INCOME *divided by* EQUITY. *A* FINANCIAL RATIO *used to judge return to critical aggregates.*
Return on sales. *Net* INCOME *divided by revenue. A* FINANCIAL RATIO *used to judge return to critical aggregates.*
Reutlinger, Shlomo, 371
Revenue, 206
income statement and, 195, 196
incremental net benefit before financing calculations and, 212
project preparation and tax, 421
Riley, J. Paul, 234, 235, 240
Ripman, Hugh, B., 12
Risk
analysis of, 9–10, 371
creditworthiness ratios and, 207
cropping patterns and, 91
rent recovery and, 231
technology and, 30
Risk analysis. *An analytical technique in which probabilities of occurrence are determined for all critical* PROJECT *elements and then, by computer, repeated computations of a* MEASURE OF PROJECT WORTH *are made, each element entering in successive computations according to its probability of occurrence. The result is most commonly reported in the form of a cumulative probability curve plotted on a graph in which the vertical axis represents the probability a measure of project worth will fall below a stated value and the horizontal axis represents the values of the measure of project worth. Sometimes called "probability analysis." Compare with* SENSITIVITY ANALYSIS. *See Reutlinger (1970) and Pouliquen (1970).*
River basin development projects, 388, 389–93
Road projects, 382–83
Rural development, 15
new technology and, 30
Rural development projects, 281–84, 388
Rural Infrastructure Project (Korea), 281–84
Rural poor, effect of projects on income of, 28

Sales (herd), 112, *114*, 116, 117
accounting convention and, 164, 165

farm budget and, 133
farm investment and, 123
feed budget and, 187
herd growth and, 183
herd projection and, 163
Sales (rent recovery computation), 229
Sales (return on), 206–07
Salvage value. *See also* RESIDUAL VALUE
of capital assets, 118
measure of project worth calculations and, 398
Sanitation projects, 280
Saving
cost recovery and public, 224
economic values determination and, 246
Savings weight. *The relative importance attached to the use of* BENEFIT *from a* PROJECT *for saving as opposed to consumption. In general, saving is considered the more valuable objective. The amount of the benefit that will be saved is weighted by the savings weight so that the final* MEASURE OF PROJECT WORTH *will favor those projects that lead to greater saving. See Squire and van der Tak (1975) Compare with* DISTRIBUTION WEIGHT
Schaefer-Kehnert, Walter, 95, 140, 163
Schistosomiasis, 15
Schwab, Gerald D., 90
Sea Defense Project (Guyana), 47–48
Seasonality
market price determination and, 73
project preparation and, 417
valuing labor and, 258, 261–62
Secondary. *With reference to* COSTS *and* BENEFITS, *a cost or benefit that arises outside the primary* PROJECT *accounts as a result of the costs or benefits of the project working through the* MULTIPLIER *effect. In* PROJECT ANALYSIS, *systems that use* VALUE IN USE *or* OPPORTUNITY COST *as the value criterion in* ECONOMIC ANALYSIS *(such as the system in this book and most systems used by international agencies), secondary costs do not exist because all costs and benefits in the project are adjusted to reflect their effect on* NATIONAL INCOME. *An allowance for secondary costs and benefits is needed only if an estimate of economic effect is to be made using* MARKET PRICES *only, as in the system used in the United States for natural resources projects.* See BENEFIT; COST; ASSOCIATED COST
Sector survey, project identification and, 22
Selection. *See* Project selection
Selling, general, and administrative expense. *A section on an* INCOME STATEMENT *that combines certain overhead expenses connected with marketing costs and administration of the enterprise. Compare with* OPERATING EXPENSE
income statement and, 196
incremental net benefit before financing calculations and, 212
Senegal River Development Program, 233–40
Sensitivity analysis. *An analytical technique to test systematically what happens to the earning capacity of a* PROJECT *if events differ from the estimates made about them in planning. A means of dealing with uncertainty about future events and values. A sensitivity analysis is done by varying one element or a combination of elements and determining the effect of that change on the outcome, most often on the* MEASURE OF PROJECT WORTH. *In agricultural* PROJECT ANALYSIS, *most projects should be tested at least for the effects on earning capacity of changes in* PRICES, *cost* OVERRUN, *delay in implementation, and changes in* YIELD. *Sensitivity tests need not be directed at the effect of a change on a measure of project worth. A sensitivity test may be made, for example, to determine the effect of a delay in* BENEFITS *on the cash position of a farmer who has borrowed for an irrigation pump. A variation of sensitivity analysis is to determine the* SWITCHING VALUE. *Compare with* RISK ANALYSIS
project analysis and projection and, 363–65
switching value variation of, 371–73
technique of, 365–71
Separable costs–remaining benefits method, 233, 234–40. *A method of allocating* JOINT COSTS *in a* MULTIPURPOSE PROJECT *among various classes of beneficiaries. Each class of beneficiary is charged for all of any separable costs attributable to its use of the multipurpose project and then shares the joint costs in proportion to its remaining* BENEFIT *See the section on "Joint Cost Allocation" in chapter 6.*
Services, project preparation and, 419
Shadow exchange rate. *See also* SHADOW PRICE

foreign exchange premium and, 248–49
indirectly traded items and, 266, 267, 269
Shadow price. *The value used in* ECONOMIC ANALYSIS *for a* COST *or a* BENEFIT *in a* PROJECT *when the* MARKET PRICE *is felt to be a poor estimate of* ECONOMIC VALUE. *Generally used as a synonym for "accounting price." Shadow price technically implies a* PRICE *that has been derived from a complex mathematical model (for example, from* LINEAR PROGRAMMING), *whereas an accounting price simply indicates that the price is not a market price. In current usage, this distinction has largely been lost, and shadow price is generally used for both purposes. In this book, shadow prices are estimates of* EFFICIENCY PRICES. *For* FINAL *goods and services, the shadow price is the* VALUE IN USE. *For* INTERMEDIATE *goods and services, the shadow price is the* OPPORTUNITY COST, *the benefit forgone by using a scarce resource for one purpose instead of its next best alternative use. Opportunity cost, for intermediate goods and services is by definition equal to the* MARGINAL VALUE PRODUCT, *the value of additional* OUTPUT *generated by an additional unit of variable* INPUT. *The "shadow wage rate" is the shadow price for labor and is generally set by estimating the marginal value product of labor. The "shadow exchange rate" is the shadow price of* FOREIGN EXCHANGE *and reflects the* FOREIGN EXCHANGE PREMIUM. *The shadow exchange rate is the* OFFICIAL EXCHANGE RATE *multiplied by 1 plus the foreign exchange premium stated in decimal form. When the* CONVERSION FACTOR *approach is used to allow for trade distortions, the opportunity cost or value in use is first multiplied by the conversion factor (often the standard conversion factor) to obtain the* ECONOMIC VALUE *used in the* ECONOMIC ANALYSIS. *See* EFFICIENCY PRICE
crossover discount rate example and, 388
defined, 243
economic analysis and, 69
economic values and, 244, 245
export and import parity prices and, 78
foreign exchange premium and, 248
joint cost allocation and, 233
secondary costs and benefits and, 60
sensitivity analysis and, 364
Shadow wage rate. *See* SHADOW PRICE
Share capital. CAPITAL *invested in an enterprise in return for a claim upon a share of any future* INCOME *distributed as* DIVIDENDS.
Sheep, 175
Short-term. *Occurring over a relatively short period. Often taken to be one year or less. In economics, a period too short to depreciate fully and replace plant and equipment. Contrast with* LONG-TERM; MEDIUM-TERM
Single purpose projects
costs and, 233
purposes in, 388, 389–90, 391, 393
Sinking fund factor. *The level deposit required each year to reach 1 by a given year. The expression* $i \div [(1 + i)^n - 1]$ *where* i = *the rate of* INTEREST *and* n = *the number of years. The reciprocal of the* COMPOUNDING FACTOR FOR 1 PER ANNUM. *Generally obtained from a set of compounding and discounting tables. This factor permits calculating the equal installment that must be set aside each year, to be invested at compound interest, in order to have a predetermined sum at a given time. It is primarily used to determine how much must be put into a fund in order to have recovered the amount of an* INVESTMENT *at the end of its useful life. Note, however, that this is a very mechanistic* DEPRECIATION *rule and may not be good management practice in many circumstances. See appendix B.*
Smallholder Dairy Improvement Project (India), 57
Smallholder Oil Palm Project (Nigeria), 288
Smidt, Seymour, 300
Social aspects of projects, 15–16
failure to appreciate, 32
project preparation report and, 413, 416–17, 419, 427–28
Social time preference rate, 314. *A rate, usually expressed in the form of a percentage, that expresses the preference of a society as a whole for present returns rather than future returns and that sometimes is proposed as a* DISCOUNT RATE *for* PROJECT ANALYSIS. *Generally considered to be less than the* OPPORTUNITY COST OF CAPITAL, *which expresses a summation of individual time preferences because the*

Social time preference rate (*continued*)
society as a whole has a longer time horizon than does any one of its members.
"Sources of Information on World Prices" (Woo 1982), 78
Sources-and-uses-of-funds analysis. *See* FUNDS FLOW ANALYSIS
Sources-and-uses-of-funds statement, 89, 190, 196. *A financial statement that measures the total flow of financial resources into and out of an enterprise during an* ACCOUNTING PERIOD *Also called the "statement of changes in financial position," "funds statement" or "funds flow statement," "sources and applications of funds statement," "statement of change in* WORKING CAPITAL," *or, sometimes, "cash flow" (not the same concept as cash flow as meant when discounted* CASH FLOW ANALYSIS *is intended).*
financial rate of return and, 211, 212
preparation of, 198–202
South Nyanza Sugar Project (Kenya)
balance sheet example and, 192–95
financial ratio examples and, 202–09
financial statement example and, 190–92
foreign exchange flow example and, 220–22
government cash flow example and, 217–20
income statement example and, 195–97
sources-and-uses-of-funds example and, 197–202
Squire, Lyn, 20, 21, 60, 246, 247, 248, 249, 254, 259, 267
Stable herd. *In* HERD PROJECTIONS, *a herd of animals that just maintains the numbers in each class and generally just consumes the feed available.*
Staffing, 33
Standard conversion factor. *See* CONVERSION FACTOR
Standard deviation. *A measure of the dispersion of a frequency distribution. Obtained by extracting the square root of the* ARITHMETIC MEAN *of the squares of the deviation of each of the class frequencies from the arithmetic mean of the frequency distribution.*
Steers
defined, 164
feed budget and, 185
herd growth and, 179, 180, 181
stable herd determination and, 177, 178, 179
Stemming-from benefit. *A form of indirect* BENEFIT *that accrues to purchasers of project* OUTPUTS *that are themselves* INTERMEDIATE *products. The direct and indirect* VALUE ADDED *generated in forward-linked industries. For example, cotton that is produced by an agricultural project and that would be used in existing cotton gins having unused production capacity might allow those gins to create additional value added that would not exist without the project. Stemming-from benefits sometimes are calculated using specialized input-output* MULTIPLIERS. *Would not normally exist where project outputs are* TRADED, *since the same stemming-from benefits could be had by increasing imports of the intermediate product or by diverting exports (see* TRADED*) to local use. A category of benefits normally identified in water resource programs in the United States. Numerous studies have indicated that substantial potential exists for misusing concepts of stemming-from benefit in* PROJECT ANALYSIS.
Storage, 57–58
project choice example and, 386
Straight-line depreciation. *See* DEPRECIATION
Stream. *A series. A sequence of values extending over several years that may then be called a "time stream." The particular variation in amount of a stream from year to year may be referred to as its "pattern."*
Subsidies
direct transfer payments and, 50, 51–52
economic analysis and, 19
farm budget calculations and, 132
financial price adjustment (transfer payments) and, 251
income statement and, 197
incremental net benefit before financing calculations and, 212
indirectly traded items and export, 267
sources-and-uses-of-funds statement and, 199
Subsidy *A* TRANSFER PAYMENT. *A direct subsidy is a payment made by a government to a producer (such as a farmer) and is a direct transfer payment. An indirect subsidy may occur when manipulation of the market produces a* PRICE *other than that which would have been reached in a*

perfectly competitive market. The BENEFIT *received by a producer or consumer as a result of this difference constitutes an indirect transfer payment. Indirect subsidies may be transfers from other parties in the society or from the government.*
Sudan, Rahad Irrigation Project in, 74, 78–80, 271, *272–75*
Sunk cost, 55. *A* COST *incurred in the past that cannot be retrieved as a* RESIDUAL VALUE *from an earlier* INVESTMENT. *A sunk cost is not an* OPPORTUNITY COST *and thus is not included among the costs when a proposed* PROJECT *or other investment is analyzed; only future return to future cost is considered. In economics, sunk cost is equivalent to fixed cost in* SHORT-TERM *decisionmaking.*
Suppliers' credit. *Term loans offered by a seller for the purchase of his goods or services.*
Support systems
  poor project analysis and, 31–32
  project preparation and, 419
Survival rate. *With reference to livestock, the proportion of animals at the beginning of a time period that live to the end of the period; 1 less the* MORTALITY RATE *expressed in decimal form. Generally expressed as a percentage.*
Switching value. *The value an element of a* PROJECT *would have to reach as a result of a change in an unfavorable direction before the project no longer meets the minimum level of acceptability as indicated by one of the measures of* PROJECT WORTH. *See* SENSITIVITY ANALYSIS
Switching value method (sensitivity analysis variation), 371–73
Sykes, Allen, 300, 341
Syria, First Livestock Development Project in, 47

Tangible. *In project analysis, a* COST *or* BENEFIT *that is capable of being appraised at an actual or approximate* PRICE *or* ECONOMIC VALUE. *Distinguished from* INTANGIBLE. *See also* REAL
Tariff, 277. *(1) A* DUTY *or* TAX *imposed on an import or export. (2) A schedule of charges of a business, especially of a public utility.*
Taste preference, farmers and, 44
Tax. *A charge, usually money, imposed by a governmental authority upon persons or property for public purposes. A tax is a* TRANSFER PAYMENT. *A "direct" tax is a tax that is difficult to shift to another person; examples include income taxes, inheritance taxes, and poll taxes. An "indirect" tax is a tax that can fairly readily be shifted, or the burden passed on, to someone else by the taxpayer; examples include sales taxes and import duties, which are generally added to the sale price of a good. See* TRANSFER PAYMENT
Taxes
  cost recovery example and, 224, 225–26
  cost recovery index and, 228
  debt service ratio on before-tax basis and, 209
  direct transfer payments and, 50, 51, 52
  economic analysis and, 19, 317
  export, 216
  farm budget and, 133
  financial price adjustment (transfer payments) and, 251
  financial rate of return and, 209, 212
  government cash flow and, 219
  income, 133, 197, 201, 212, 318
  income statement and, 197
  indirect (incremental net benefit before financing calculations), 211
  payable (but not yet paid), 195
  project costs and, 54
  rent recovery and, 231, 232
Taylor, Lance, 248
Technical analysis, 12–13
Technical change, project implementation and, 24
Technical coefficients
  adult mortality, 166
  animal units, 174–75
  calf mortality, 166
  calving rate, 166
  culling rates, 166–67
  herd growth, 179–83
  herd projections and, 113, 115–16, 117, 163, 165–83
  ratio of bulls to breeding females, 167–74
  stable herd determination and, 175–79
Technology
  farm investment analysis and, 91, 92, 93–94
  implementation and inappropriate, 30–31
  mutually exclusive projects and, 383–88
  new, 30, 31
  obsolescence in, 9
  secondary costs and benefits and, 61

Tenant farmers, 15
Tenure, project preparation and, 416
Terminal value. *See* RESIDUAL VALUE
Third Agricultural Credit Project (Kenya), 140–41, 147–50
Third Highway Loan Project (Kenya), 382–83
Time-adjusted *Refers to an accounting convention in which the first year of an investment analysis is used solely for* INVESTMENT *and in which incremental* BENEFITS *appear only from year 2 or later (Schaefer-Kehnert 1978). Used for* FARM INVESTMENT ANALYSIS *to make the analysis congruent with the assumption of* DISCOUNTED CASH FLOW ANALYSIS.
Time-adjusted accounting convention. *See* Accounting convention (time-adjusted)
Time adjustment, benefits and, 57
Time overruns (project), 27, 28–29
Time-slice. *See* PROJECT
Time value of money. *An expression referring to the concept that values received earlier are worth more than values received later. The concept underlying* DISCOUNTING.
  discounted measures of project worth and, 313
  discounting convention for project analysis and, 315
  discounting present worth and, 308–09
  discount rate choice and, 313–15
  income stream and, 309–13
  interest computations and, 305–08
  mutually exclusive project example and, 387
  sensitivity analysis and, 369
Timing. *With reference to* PROJECTS, *the choice of time to begin project implementation. When project* BENEFITS *will grow independently of project* COSTS, *it may be desirable to postpone a project.*
  mutually exclusive projects and, 381–83
Tradable. *Capable of being* TRADED *"Tradable but nontraded" goods and services are those which are not traded because of government regulation. In* ECONOMIC ANALYSIS, *they are treated as* NONTRADED *items if the regulation is expected to persist during the period under analysis.*
Tradable but nontraded items (financial price adjustment), 263–65. *See also* TRADABLE.
Traded. *A project* INPUT *or* OUTPUT *is traded if its production or consumption will affect a country's level of imports or exports on the margin (see* MARGINAL ANALYSIS*). In* ECONOMIC ANALYSIS, *the value of traded items is based on their* BORDER PRICE. IMPORTS *and* IMPORT SUBSTITUTES *are valued at the import* PARITY *price, which is the* C.I.F. *value adjusted for domestic costs between the* PROJECT *and the point of entry. Exports and* DIVERTED EXPORTS *are valued at the* F.O.B. *value adjusted for domestic costs between the project and the point of export.*
Traded goods
  export and import parity values and, 269
  financial price adjustment and, 251–53
  foreign exchange premium and, 247–48, 249–50
Trade policy changes, economic values determination and, 271–78
Transfer payment. *A payment made without receiving any good or service in return (except, perhaps, the service involved in making the transfer payment). A "direct" transfer payment occurs when a payment is made that directly shifts claims to goods and services from one entity to another entity in the society. In agricultural* PROJECTS, *the most common direct transfer payments are* TAXES *and direct* SUBSIDIES *Other examples are charitable contributions and welfare payments In* PROJECT ANALYSIS, *loans and* DEBT SERVICE*—payment of* INTEREST *and repayment of* PRINCIPAL*—are treated as transfer payments because the loan terms only divide the claims to goods and services between borrowers and lenders and do not affect the total amount of the* RETURN TO CAPITAL. *When a* PRICE *differs from the* MARGINAL VALUE PRODUCT *or* VALUE IN USE, *an "indirect" transfer payment occurs equal to the difference Since transfer payments represent shifts in claims to goods and services only and not use or new production, they do not increase or reduce* NATIONAL INCOME; *hence, they are omitted when converting accounts used in* FINANCIAL ANALYSIS *to* ECONOMIC VALUES *used in* ECONOMIC ANALYSIS.
  costs and benefits and direct, 50–52
  economic analysis and, 19, 317
  financial price adjustment and, 251
  incremental net benefit and, 129
  project costs and, 55

Transport, benefits and, 58, 59
Transport projects, 255
Treatment of uncertainty. *See* SENSITIVITY ANALYSIS
Tree crop projects
  completion time and, 28
  rate of return estimates and, 27–28
Tunisia, forestry project in, 386–88, *389*
Turvey, Ralph, 59, 300

Uncertainty. *See* Risk; SENSITIVITY ANALYSIS
Undiscounted measures of project worth, 300–04. *See also* MEASURE OF PROJECT WORTH
UNDP. *See* United Nations Development Programme (UNDP)
Unemployment, seasonal employment and, 261, 262, 416–17
Unit activity budget. *In* FARM INVESTMENT ANALYSIS, *a* FARM BUDGET *based on an easily segregated activity such as planting a single hectare of a crop or raising a particular group of animals. It is difficult to prepare a unit activity budget on a* WITH AND WITHOUT *basis; rather, it is generally prepared on an incremental basis, with all* COSTS *and all* BENEFITS *included at the incremental value. For both* FINANCIAL ANALYSIS *and* ECONOMIC ANALYSIS, *this means that for some elements the* OPPORTUNITY COST *must be estimated directly, often especially difficult for land and for* FAMILY LABOR. *As a result, unit activity budgets are most appropriate in project analyses where the opportunity cost of land and family labor can be taken to be zero. Distinguished from* WHOLE FARM BUDGET. *See also* PARTIAL BUDGET
  cashew production example (India) of, 142–46
  crops (aggregation methods) and, 287–89, 291
  defined, 141
  net financing and, 146–47
  opportunity costs and, 142, 143, 146
United Nations Development Programme (UNDP), 438–39
United Nations Industrial Development Organization (UNIDO), 441
Upper, Jack L., 190, 203
Upper Region Agricultural Development Project (Ghana), 290, 291
User fee. *A charge levied upon users for the services rendered or goods supplied by a* PROJECT. *See also* COST RECOVERY INDEX *and rent recovery index.*
  aggregation and, 289
  agricultural projects and, 216
  government cash flow and, 219

Valuation
  aggregation and, 293–94
  incremental residual value and, 117–19, *120, 121*
  intangible costs and benefits and, 61–62, 280
  price system based on, 11
  projected farm production and, 117, *120*
Value. *See* ECONOMIC VALUE
Value added. *The amount of* ECONOMIC VALUE *generated by the activity carried on within each production unit in the economy. Every farm, every factory, every hospital and school, every road and shop and cinema—each unit generates its own value added. The sum of all the value added generated by all production units equals the total production of the country, its* NATIONAL INCOME *measured as* GDP *(gross domestic product) or* GNP *(gross national product). In any production unit, value added is measured by the difference between the value of the* OUTPUT *of the firm and the value of all* INPUTS *purchased from outside the firm. Thus, the value of output minus the value of externally purchased inputs equals the value added. The* CAPITAL *and labor attached to each firm are considered internal inputs, not externally purchased inputs. "Gross value added" represents the pool of* INCOME, *generated by production, that is distributed to the* FACTORS OF PRODUCTION *attached to the firm, including income* TAXES *and* DEPRECIATION. *Deducting depreciation gives the net value added; the sum of all the net value added generated by production units in the economy is the net domestic product. "Domestic value added" refers to the value added by local or domestic activities to components imported from abroad. Domestic value added in an* INDIRECTLY TRADED *item is the total value of the product less the* BORDER PRICE *of the imported components. A "value added tax" is an* INDIRECT TAX *(also known as an "ad valorem tax"—the Latin phrase means "according to the value") levied at the time of each exchange of goods and services from primary production to consumption,*

Value added (*continued*)
generally stated as a proportion of the value added at each stage of production.
aggregation methods and, 293, 294
indirectly taxed items calculation and, 266
as indirect tax (income statement), 197
secondary costs and benefits and, 60
Value of production forgone. *The reduction in* OUTPUT *or reduction in* NET BENEFIT *that is a result of changing the use of an* INPUT *from one activity to another. The value of production forgone is the* OPPORTUNITY COST.
Value in use. *A criterion of value in* ECONOMIC ANALYSIS *that takes as the* ECONOMIC VALUE *of* FINAL *goods and services the amount a purchaser is prepared to pay—that is, the purchaser's* WILLINGNESS TO PAY *Distinguished from the criterion for* INTERMEDIATE *goods and services, for which the economic value is taken as the* MARGINAL VALUE PRODUCT *when that good or service is used to produce some other good or service. Either the value in use or the marginal value product of a good or service becomes the* OPPORTUNITY COST *when that good or service is shifted to another use.*
van der Tak, Herman G., 20, 21, 60, 246, 247, 248, 249, 254, 269

Wage rates, valuing labor and, 258–63
Wages
development and rise in, 76
off-farm, 138
Ward, William A., 247
Water charges, 216
aggregation and, 289
cost recovery example and, 223–24, 225–26
rent recovery and, 232
Water pollution, 16
Water resources planning publication (1979), 345
Water resources, project preparation and, 415
Weight The relative importance attached to some item. *See* DISTRIBUTION WEIGHT; SAVINGS WEIGHT
West Africa. *See also specific countries*
price policy example and, 35
social environment example and, 32
Whole farm budget. *A budget for all activities on a farm. Distinguished from* PARTIAL *and* UNIT ACTIVITY BUDGETS. *See also* FARM BUDGET; PATTERN FARM PLAN
Willingness to pay, 60, 254. *The amount consumers are prepared to pay for a* FINAL *good or service. An estimate of the* VALUE IN USE.
economic values and, 245
foreign exchange premium and, 250
With and without. *Refer to the situations with and without a proposed project. In* PROJECT ANALYSIS, *the relevant comparison is the* NET BENEFIT *with the project compared with the net benefit without the project. This is distinguished from a "before and after" comparison because even without the project the net benefit in the project area may change.*
With and without comparisons, costs and benefits of proposed projects and, 47–50
Without-project incremental net benefit, 128
Without-project net benefit after financing, 212, 213
Without-project situations
aggregation and, 291
expansion and, 191
family labor and, 138
land costs and, 139–40
valuing labor and, 260
With-project farm budget, 127
debt service and, 134
With-project situations
aggregation and, 291
expansion and, 191
family labor and, 138
land costs and, 139–40
valuing labor and, 260
Work day *The time devoted to an activity by one person during one day. In agricultural* PROJECTS *in developing countries, a work day is generally taken to be eight hours in duration, but in some agricultural situations a work day of six hours is more realistic A standard work day may sometimes be established. It is usually the work day of an adult male, with the work of women and children assigned some proportion of that standard.*
Working capital. *The* CAPITAL *necessary to purchase goods and services that are used for the production activities of an enterprise and that are turned over during the production cycle. For farms, the capital necessary to purchase supplies (such as seed and fertilizer) and services (such as agricultu-*

ral labor) needed during the production of crops or livestock. The working capital is then recovered when the crops or livestock are sold and so is available for use in a subsequent production cycle. From an accounting standpoint, literally all current ASSETS. *"Net working capital" is the difference between current assets and current* LIABILITIES. *In practice, working capital frequently also means net working capital.*
farm investment analysis and, 98–99, 126–27
residual value and, 118–19
sources-and-uses-of-funds statement and, 202
Work oxen
computational conventions and, 165
culling rate and, 167
herd growth and, 180, 181
stable herd determination and, 177, 178
Work year. *The time devoted to an activity by one person during the course of one year. A standard work year may sometimes be established. It is usually the work year of an adult male, with the work of women and children assigned some proportion of that standard.*
World Bank, 4, 76, 246, 359, 365, 438
computer use and, 408
consultant assistance and, 441, 442
cost recovery and, 226
government cash flow example and loan from, 219
project analysis techniques and, 10
project audits (reviews) and, 26–27, 28, 29–30
projections of, 117
project preparation reports and, 411, 440–41
sources-and-uses-of-funds example and loan from, 198

Yield, 365, 369. *In agricultural use, the production of a crop or fodder per unit of area (for example, tons per hectare). In financial use, the* RATE OF RETURN *on* AN INVESTMENT. *See also* High-yielding seed

J. PRICE GITTINGER is coordinator of training materials and publications and lectures on project analysis in the Economic Development Institute (EDI) of the World Bank.

The full range of World Bank publications is described in the *Catalog of World Bank Publications*; the continuing research program is outlined in *World Bank Research Program: Abstracts of Current Studies*. The most recent edition of each is available from the Publications Unit, World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. Training materials and publications of EDI are described in the *EDI Catalog of Training Materials*; the most recent edition is available from the Training Materials and Publications Unit, EDI, World Bank, 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. All three booklets are available without charge and are updated annually.

Books of related interest from the World Bank and Johns Hopkins

Agroindustrial Project Analysis
James E. Austin

Enterprises that process agricultural raw materials—agroindustries—contribute significantly to the economic growth of developing countries. This book provides a unified approach to the analysis of agroindustrial projects and the dual agricultural and manufacturing nature of such enterprises.

Farm Budgets: From Income Analysis to Agricultural Project Analysis
Maxwell L. Brown

This book clarifies the relation between simple farm income analysis, which seeks to describe the annual profitability of a single farm, and agricultural project analysis, which seeks to forecast the income-generating performance of a project comprising one or more farms for the lifetime of the project. The transitions between the two analyses and the budgets necessary at each stage are clearly presented.

Economic Analysis of Projects
Lyn Squire and Herman G. van der Tak

This book presents a methodology of project analysis that incorporates a more systematic and consistent estimation and application of shadow prices than had previously been used by the World Bank and other development agencies. Methods are demonstrated for calculating rates of return that take explicit account of the effect of a project on the distribution of income, both between investment and consumption and between rich and poor.

The Johns Hopkins University Press
Baltimore and London

ISBN 0–8018–2913–5

Cover: Design by Joyce C. Eisen, photograph by Edwin Huffman.