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ABSTRACT

AGRICULTURAL MECHANIZATION IN ETHIOPIA: AN ECONOMIC ANALYSIS OF FOUR CASE STUDIES

By

David Alfred George Green

Four dissimilar cases of agricultural mechanization in different regions of Ethiopia are described and analyzed for potential benefits, costs, and compatability with certain objectives selected from the Ethiopian Third Five-Year Plan. The broad definition of mechanization is employed: any form of mechanical assistance used in agricultural technology, facilitates consideration of any agricultural system in Ethiopia as a potential site for mechanization.

Objectives of the thesis are: to present production data over a period of ten years for which farm budgeting is employed; to analyze the financial data with benefit-cost techniques to relate certain non-financial aspects of these cases to objectives specified in Ethiopian development plans for which index trends were estimated; to demonstrate the types of data required for economic analyses of agricultural mechanization; to demonstrate the applicability of the methodology to four different agricultural systems.

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Systems are classified as employing hand-, animal-, or engine-powered technology. The selected cases depict four alternative options open to policy-makers interested in improving agricultural mechanized technology in Ethiopia. Mechanization is regarded as a process of improvement or transition.

Potential commercial viability is the principal criterion employed for selection of cases. No value is placed in mechanization per se without economic justification for proposed changes. Hence, introduction of cash crops into the agricultural systems are essential.

The selected cases depict systems of hand-powered agriculture (a village subsistence economy in southwestern Ethiopia--72 hectares), animal-powered agriculture (a small family farm in the Central Ethiopian Highlands--8 hectares), and two cases of engine-powered agriculture (a large commercial farm in northwestern Ethiopia--800 hectares and a plantation in eastern Ethiopia--10,000 hectares). In each case, two yield levels (maximum and minimum) are investigated and two strategies for three of the cases. One strategy for the village economy provides for the introduction of improved hand tools and storage equipment; two strategies for the small farm provide for either improvement in oxen technology or the introduction of tractor hire services, two strategies for the large commercial farm provide for intensive labor utilization mechani

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or intensive mechanization; two strategies for the plantation provide for raw cotton or ginned cotton production each using engine-powered technology in early tillage operation and intensive hand labor subsequently.

Benefit-cost analysis is used to establish seven indicators of primary net benefits from the financial accounts: net present value, payback period, internal rate of return, benefit-cost ratio, and average net present value for each of three arbitrarily designated scarce resources (investment capital, wage costs for technical personnel, wage and supporting costs for technical personnel). Cases are ranked according to each criterion. Sensitivity analyses consist of examining the effect of changing selected parameters in the system on the values for benefit-cost criteria and the total change in benefit-cost results caused by changes in prices for marketed outputs and wages.

Objectives selected from the Ethiopian Third Five-Year Plan for additional investigation of non-monetary aspects of the cases are: income generation, employment and wage distribution; productivity of factors; potentials for export and import substitution. Relative changes in these non-monetary aspects are measured by indices computed at selected points in time.

Substantive conclusions are drawn from the results of case study analyses without attempting generalization either for Ethiopia or Equatorial Africa. Methodological generalizations are presented as the procedures employed have general application.

Recommendations from the experience and work involved in the thesis are directed to policy-makers concerned with introduction of mechanized agricultural technology in Ethiopia. Attention is drawn to the importance of dialogue between policy-makers and research investigators in the design of both policy and research programs. Recommendations relate to the following: (1) questions about the role of agricultural mechanization; (2) specific questions of selection and implementation among alternative programs; (3) project appraisal; (4) project establishment; (5) research organization and priorities.

AGRICULTURAL MECHANIZATION IN ETHIOPIA: AN ECONOMIC ANALYSIS OF FOUR CASE STUDIES

By

David Alfred George Green

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1971

. . . where shall I find help?
Help comes only from the Lord,
maker of heaven and earth.
(Psalm 121, NEB)

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FOREWORD

The Mechanization Study[1] which provided the means of obtaining information and initial data employed in this thesis extended over a period of 35 months, from 1 February 1967 to 31 December 1969. Primary attention was focused on agricultural mechanization in Ethiopia and Ghana; field observations also included extensive travel in The Gambia, The Ivory Coast, Kenya, Nigeria, Senegal, and Tanzania.[2] The territory covered by the Study lies within the broad geographical area of Equatorial Africa, hence the title of the final report,[3] to which this thesis is a sequel.

The objectives of this thesis are more limited than those of the Mechanization Study. Certain economic

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[1]Undertaken by Michigan State University in contract with the United States Agency for International Development (Contract AID/afr--459).

[2]The author participated in field work from 1 July 1968 to 15 April 1969 as one member of the four-man team. This team was interdisciplinary within the agricultural disciplines; other members were two agricultural engineers and one agronomist.

[3]C. K. Kline, D. A. G. Green, Roy L. Donahue, B. A. Stout, Agricultural Mechanization in Equatorial Africa, Research Report No. 6 (East Lansing: Institute of International Agriculture, Michigan State University, 1969).

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aspects of the problem of agricultural mechanization found in four Ethiopian case studies have been examined and analyzed. The entire inquiry of this thesis is circumscribed by the delimitations of the Ethiopian economy. Through the objectives of the thesis a methodology is presented to demonstrate a suitable means to effect an economic analysis from a selection of available technical data.

Research for this thesis was carried out in four methodological phases. The first two phases, consisting of field observations of the selected cases and preparation of production data to depict the initiating conditions of the productive processes observed in each agricultural system, were complete when the Mechanization Study terminated. These were conducted largely in Ethiopia. The second two phases, consisting of preparation of budget models and analyses of generated data, were conducted in East Lansing.

Standard international units of measure have been employed in the thesis. Within the confines of Equatorial Africa, the scope of the Mechanization Study was international; to coordinate the large number of data sources, units were converted into the metric system and monetary values to United States dollars. The problem of agricultural mechanization in Equatorial Africa is an international problem, providing an area of inquiry for a mber of spe

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number of specific studies in several national economies. Economic generalizations about mechanization in Equatorial Africa are likely to become possible, and more likely to be given credence, as the results of similar inquiries from different countries become available. Thus, to facilitate such an approach to an international problem of considerable importance, the case studies used in this thesis are developed and analyzed in the international units in which they were originally prepared. In the benefit-cost analyses and trends expressed as indices, the final results are independent of the units of measure employed. For use within Ethiopia, the budget data can be multiplied by a factor of 2.5 to convert United States dollars into Ethiopian dollars.[1]

The Julian calendar is used in Ethiopia. However, in common with most scientific investigations, all dates other than those appearing in citations are expressed in terms of the Gregorian calendar.

A further comment is necessary on standardization, with respect to the spelling of Ethiopian names and places. Ethiopian words are transliterated from Amharic into English and appear in a great variety of spellings. So far as has been possible, in this thesis, spellings of

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[1]Units of measure and currency are contained in Appendix H.

Ethiopian names and other Amharic words have followed those adopted by the Economic Commission for Africa at the First United Nations Conference for Africa, held in Nairobi, Kenya, in 1963.

The author is indebted to a large number of individuals for help and interest during the course of employment with the Mechanization Study and, subsequently, in the preparation of this thesis. These studies have been aided by the United States Agency for International Development and the Department of Agricultural Engineering at Michigan State University under whose auspices field work in Africa was conducted, and the Department of Agricultural Economics at Michigan State University in which the author has been a graduate assistant.

During the course of conducting field work, office accommodation and professional facilities were made available at the Institute of Agricultural Research in Addis Abeba, Ethiopia, through the kindness of Ato Werqu Mekasha at that time Director of the Institute and Assistant Minister, and Dr. Ibrahim Abu Sharr, the concurrent FAO Project Manager of the Institute. Also on the staff of the Institute of Agricultural Research, a debt of gratitude is due Ato Seyoum Solomon and Ato Solomon Bellete, Assistant Research Officers, who both assisted so admirably in many field trips; to Woizerit Maigenet Shifferraw for exemplary devotion to her secretarial duties and to Woizero Dalhia Mazengia for secretarial and administrative assistance.

At the USAID Mission in Ethiopia, Dr. John L. Fischer, Chief, Food and Agricultural Division during the field work period of the Mechanization Study, gave constant help, interest, and logistic support. During the field work phase, Mr. Cernyw K. Kline, Department of Agricultural Engineering, Michigan State University, whose notable dexterity in combining duties of administration and engineering research relieved other Team members of many burdensome chores in the field, is to be thanked; Dr. Roy L. Donahue, Professor, Department of Crop and Soil Science, Michigan State University, proved a ready and constant help particularly in matters of agronomy. Mr. Charles F. Doane, Jr., Administrative Officer of the Mechanization Study, is to be thanked for effectively easing the burden of personal and project administration.

Members of the Stanford Research Institute Team working in Ethiopia at the same time under the direction of Dr. Clarence J. Miller provided congenial professional support.

Special appreciation is due to Dr. Glenn L. Johnson for his continual guidance and persistent encouragement over the past six years as the author's major

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professor. He has proved to be both a hard taskmaster and a wise and sincere counselor. Appreciation is also due to Dr. L. L. Boger, Dean of the College of Agriculture and Natural Resources, and to Dr. Dale E. Hathaway, Chairman of the Department of Agricultural Economics, Michigan State University, for the position and financial support which made graduate studies in Agricultural Economics possible.

Thanks must be expressed to members of the Guidance Committee who directed the program of studies: Dr. Carl K. Eicher, Dr. Robert D. Stevens, Dr. Lester V. Manderscheid, Department of Agricultural Economics; Dr. Victor E. Smith, Department of Economics; Dr. Harvey M. Choldin, Department of Sociology; and Dr. B. A. Stout, Chairman, Department of Agricultural Engineering, who also coordinated the activities of the Mechanization Study.

Gratitude is expressed to Mr. Robert F. Ranger for his help with the adaptation of his computer program for benefit-cost analysis which is employed in this thesis. Recognition is due for excellent facilities of the Michigan State University Computer Center; and gratitude is extended for the kind cooperation of Miss Laura J. Robinson, Programming Supervisor, Agricultural Economics Section; to Mr. Daniel C. Tsai for the preparation of the program for the CDC 3600 computer; to Mr. William R. Paley for

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preparation of the program for the CDC 6500 computer; and to Mrs. Russell Tropp for her labor on the keypuncher.

Thanks are due to Mrs. Dennis Campbell, Miss Kathryn Kohl, Mrs. Gaylord Walker who each helped in parts of first typings and to Mrs. Carolyn Piersma who handled the final preparation of this thesis.

Finally sincere appreciation is due to Norma who has shared in this entire experience and whose constant help and presence were those which only a wife can give; and to Evelyn, the author's mother whose patience has prevented distance from meaning separation.

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CHAPTER I

INTRODUCTION

Definition of Agricultural Mechanization

A broad definition of agricultural mechanization is employed in this thesis: all forms of mechanical assistance used at any level of sophistication in agricultural technology are considered to be aspects of agricultural mechanization. Thus, hand tools, animal-powered and engine-powered equipment are all included in this definition.[1]

Operating under this broad definition, the scope of a mechanization study may include any agricultural system found in Ethiopia. A classification of systems selected for study and a means of determining the form of technology to be considered in the study are clearly desirable in order to define the context and the nature of the investigation. Construed in recognizable

[1]This definition contrasts sharply with that preferred by de Wilde who uses the term, ". . . in the narrow and more popular sense as referring only to motorized or tractor-drawn equipment, rather than to all machinery, including that employing animal draft." John C. de Wilde, Experiences with Agricultural Development in Tropical Agriculture, Vol. I: The Synthesis (Baltimore: The Johns Hopkins Press, 1967), p. 95.

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categories, mechanization provides a means of classification for functional systems; construed in terms of processes, mechanization provides a means of identifying change taking place within each system. Appropriateness of mechanization is taken into account in determining the form of technology to be introduced into a given system.

Categories and Processes of Mechanization

Mechanization can be construed in three distinct categories: hand-, animal-, and engine-powered technology. Within the limitations of appropriateness, discussed below, these categories represent alternative forms of mechanization, or options open to decision-makers, to be introduced into agricultural systems selected for improvement. Agricultural systems can be similarly classified. However, the dynamic systems of the real world do not fall neatly into these precise categories since many systems can be observed simultaneously to be in a process of change, and in transition from one form of power to another. Thus, agricultural mechanization, when viewed in the dynamic context of economic development, is manifested in the real world in six different operational processes:

1. Processes of improvement (within categories), (a) in hand-powered technology, (b) in animal-powered technology, (c) in engine-powered technology.

2. Processes of transition (between categories), (a) from hand-powered to animal-powered technology, (b) from animal-powered to engine-powered technology, (c) from hand-powered directly to engine-powered technology. (Conceptually, these transitional processes can also be reversible.)

Appropriateness of Mechanization

Appropriateness of the form of mechanization employed in the agricultural system under investigation may be considered from a technical or an economic point of view, different connotations which tend to lead to misunderstandings among agricultural professionals. The technical interpretation implies operational suitability of machines and equipment in contrast to the economic interpretation which implies efficiency in terms of net returns taking into account the socio-economic framework of institutions, infrastructure, and market structure required to support the particular form of mechanized technology under consideration. In the technical sense, appropriate mechanized improvement implies technical workability; in the economic sense, appropriate mechanized improvement is subsumed under the general condition of commercial viability which includes technical appropriateness. In this thesis a major criterion for selecting forms of mechanization is economic appropriateness; both interpretati

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interpretations, however, warrant consideration especially since discussion may serve to clarify misunderstanding where it exists.

Appropriateness in the technical sense is generally related directly to increasing agricultural productivity. The potential for increasing productivity through the employment of a selected form of mechanized technology is found chiefly in two circumstances: (1) where it relieves pressure on labor at seasonal peaks, i.e., where labor is a limiting factor or "bottleneck"; (2) where increase in production depends upon the performance of tasks which manual labor cannot do without mechanical assistance.[1] Elimination of "bottlenecks" should permit more effective and fuller utilization of labor resources over the agricultural season although there is a danger of introducing machinery into an agricultural system which relieves one bottleneck and creates another.[2]

> The benefits of mechanisation in developing countries are, of course, potentially the same as anywhere else, but opportunities for realising them will differ with the existing economic and environmental circumstances.[3]

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[1]Herman M. Southworth and Bruce F. Johnston, Agricultural Development and Economic Growth (Ithaca, N.Y.: Cornell University Press, 1967), p. 216.

[2]De Wilde, op. cit., pp. 97-103.

[3]Malcolm Hall, "Mechanisation in East African Agriculture," in Agricultural Planning in East Africa, ed. by G. K. Helleiner (Nairobi: East African Publishing House, 1968), p. 82.

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These benefits may be itemized as: (1) increased ability to cultivate land where there is an inadequate supply of labor; (2) increased ability to perform critical tasks where labor is generally adequate for the remainder of the season; (3) increased ability to cultivate intractable soils; (4) the possibility of higher yields (although this is frequently a case of interaction among mechanization and other factors such as improved seeds and fertilizers); (5) increased speed of work; (6) higher quality and improved timeliness of agricultural operations.[1]

No assumption is made in this thesis that a natural sequence exists in the context of economic development for agricultural systems to move to higher levels of mechanization (from hand-powered through animal-powered to engine-powered forms of technology).[2] The grounds of justification for any process, either of improvement or transition, are economic; the basic underlying assumption in economic development is that the economy attempts to realize optimal returns from its available resources.[3]

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[1] Ibid., pp. 82-83.

[2] The so-called "farm-power ladder." Peter M. Weil, "The Introduction of the Ox Plow in Central Gambia" (Washington, D.C.: The National Science Foundation, 1968), p. 6. (Mimeographed.)

[3] Optimizing returns should not be confined to those objectives easily measurable in money terms. The optimization process depends on the totality of social objectives which, of course, are different between different societies and nations of people. Glenn L. Johnson, "The Role of the

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The connotation of appropriateness employed in this thesis is economic rather than technical. No particular merit is presupposed by the introduction of mechanized technology into a given agricultural system. Selective mechanization must be justified by appropriate analytical procedures furnishing evidence which indicates a positive contribution to socio-economic improvement. Agricultural mechanization is dissociated from connotations of achievement level in economic development. In the overall context of economic development, there is an appropriate form of mechanization for any given system. The perspicacity of both analyst and planner must be sufficiently sensitive to select a form of mechanization appropriate to the development of that system.

Scope and Purpose of the Thesis

The scope of this thesis is circumscribed by the economic framework of the Ethiopian Empire. The approach to the problem of agricultural mechanization adopted in this thesis is directed toward specific cases within the limits of a single national economy. Following this approach, and analyses, it appears reasonable to hypothesize that principles can be elicited which have general validity to the problem of introducing mechanized

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University and Its Economists in Economic Development" (paper presented as the J. S. McLean Visiting Professor Lecture, Publication No. AE 70/2, Guelph, Department of Agricultural Economics, University of Guelph, 23 March 1970), p. 3.

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agricultural technology into African agriculture but such generalizations are beyond the scope of this thesis. However, the methodology may provide a basis for further analytical studies of other cases of agricultural mechanization in similar economies. As more data from related case studies become available, the possibility of generalization increases.

The approach to agricultural mechanization in Ethiopia is essentially directed toward analyses of productive processes of which mechanization is a part. This approach consists of microanalyses of agricultural systems which are themselves part of the macroeconomic framework of the national economy. Indeed, microanalyses of selected agricultural systems have little meaning for the designers of economic development unless relevant macroeconomic factors are also taken into account.

Incorporated into the purpose of this thesis is a demonstration of a method of meeting the needs which policy decision-makers have for precise and detailed information about agricultural activities at production level. The gap which exists between research at production levels and planning economic development at national policy levels is given recognition. Until a substantial amount of "grass-roots" level research has been conducted and published, planners are unlikely to know with any degree of precision what can be achieved in the various sectors of the economy and the probable

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effect a policy decision is likely to have on the vast majority of people engaged at the production level in the agriculture of less developed economies.[1]

A study of mechanized agricultural technology and the processes of mechanization requires information about both mechanical components of agricultural activities and a whole range of new or improved productive factors which together are recognizable components of a given agricultural system. Relevant information includes the results of: biological inquiries into existing practices of plant and animal husbandry; research into new and/or improved varieties and breeds; fertilizer trials; technical investigations into operational requirements for labor and machinery under existing and improved farming techniques; testing implements, machinery, and equipment under prevailing conditions. In addition extensive knowledge of the nation's markets, price movements, and infrastructure to support agricultural expansion is desirable.

There is a wide range of agricultural systems in the Ethiopian economy for which precise information observed over suitable periods of time is unavailable. Data are available from the accounts of some of the few commercial organizations. Such agricultural systems, however,

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[1]Rainer Schickele, "Farm Management Research and Economic Development: Suggestions for a Specific Research Program," Indian Journal of Agricultural Economics, XXI, No. 2 (April-June, 1966), 1-7.

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are representative of an extremely small proportion of the total Ethiopian economy.

Data relevant to mechanization studies are required firstly, to represent a selected agricultural system at a given point in time and secondly, to represent manipulation of the system through time as the form of technology is changed during the course of technological improvement. In order to effect economic analyses, new data typical of relevant technical and biological changes are required. Where such observations are unavailable or incomplete, the desired data can be generated on the basis of valid assumptions and/or data transferred from similar ecological situations. The usefulness of a study, in which agricultural systems are simulated, then becomes two-fold: first, to approximate the probable effect on a selected system of a set of assumptions with respect to mechanization and concomitant changes in other inputs; second, to indicate relevant areas for future research by the extent to which assumptions and data transference were necessary.

In the use of case studies, the investigation may fall between two extreme analytical approaches: either the effect of introducing a range of different alternatives of mechanized technology into one selected agricultural system; or the effect of introducing one form of mechanized technology into a range of different agricultura

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agricultural systems. A combination of these two extremes is employed in this thesis.

The Mechanization Study[1] afforded the opportunity to collect appropriate data for several dissimilar cases in Ethiopia. Those cases selected for analysis in this thesis provide a means to demonstrate how data describing dissimilar functional systems can be employed, given appropriate assumptions, to generate new data for subsequent economic analyses. The concept of appropriateness facilitates screening out certain alternative forms of mechanization; a maximum of two different strategies were investigated in any one case.

The purpose of examining selected case studies of agricultural mechanization in Ethiopia is to provide both data and analyses to guide planning and policy related to the adoption of new agricultural technology, including new forms of mechanization. Such planning and policy-making is likely to include both planners and policy-makers of Ethiopia and donor countries willing to finance agricultural mechanization programs.

Objectives of the Thesis

The first objective is to present data of the productive processes of the cases selected to represent different agricultural systems in Ethiopia. These case

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studies have been prepared to represent functional agricultural systems into which improved forms of mechanization are introduced.

The second objective is to analyze data on these particular cases so that designers of agricultural development may have measures of the relative advantages of different selected forms of mechanization and measures of selected socio-economic changes important in development brought about by the mechanization process.

Two additional and somewhat subsidiary objectives are also incorporated. The third objective is to demonstrate by the employed methodology the types of information, data, and procedures required to effect an economic analysis of changes in mechanized technology of selected agricultural systems. The fourth objective is to demonstrate how these methodological procedures can be applied to cases of quite dissimilar agricultural systems.

The Agricultural Production Function

Available data of agricultural production in Ethiopia are insufficient, either in cross sectional or time series studies, to estimate production functions for contemporary productive processes. However, conceptualization of a function is useful in focusing attention on factors relevant to the mechanization of agricultural technology.

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Systems Approach to Productive Processes

Allusions have already been made to agricultural mechanization conceived as part of a complete system of agricultural production. Mechanized technology is not confined entirely to productive processes although in order to circumscribe the scope of this thesis to manageable proportions, the emphasis will be on mechanization in the context of production. At Ethiopia's present level of development, major attention is being focused on production along with necessary concomitant market changes.

The technique of total farm budgeting is employed in the thesis for generating data required to analyze the effect of improving mechanized technology in the productive processes of selected cases. In effect, this technique is a non-maximizing simulation of the total agricultural system. In the course of preparing the budget models, the entire socio-economic system comes under review because social processes frequently are observed to be so closely related with productive processes, especially in cases of subsistence agriculture. In attempting a total simulation of productive processes, the observer is required to be acutely aware of social processes which have economic significance in the case under investigation.[1]

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[1]Assumptions basic to contemporary economic analysis have been developed in the context of the

The systems approach takes into account all variables relevant to the productive processes within a given socio-economic system. These variables are components of the system under consideration; some variables are factors involved in the system's production functions and others are variables in the system's environment. The environment, embodying both climatic and sociological variables, is largely independent of, although exerting a strong influence on, the productive processes. Input variables of the productive processes, while part of the production function, can be controlled from outside the system and are therefore regarded, along with the environmental variables, as exogenous factors of the system. On the other hand, there are internal characteristics of the system which relate inputs and environmental variables to outputs. Thus outputs, determined by these internal characteristics, are endogenous variables. Input and output variables of the productive processes are interrelated through the system's production functions; a given system may produce several different outputs, each

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socio-economic system of more highly developed western countries. Hence, it is important to bear in mind that in the context of the socio-economic system of less developed economies the assumptions of economic efficiency in terms of the market may be invalid. "The general applicability of the production function concept has represented both a major strength and a limitation on the contribution of production economics to the understanding of development processes." Vernon W. Ruttan, "Production Economics for Agricultural Development," Indian Journal of Agricultural Economics, XXIII, No. 2 (April-June, 1965), 8.

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productive process being represented by a production function. A full understanding of the various production functions must also take into account exogenous variables of the system's environment.

Production functions can be aggregated for different systems, different sectors, and for the total economy. A total systems approach would reduce all the relevant interrelationships between exogenous and endogenous variables to a set of mathematical equations, of which the production functions, either aggregate or partial depending on the level of aggregation of the system under consideration, would be a part.

Changes in levels of mechanization are generally accompanied by concomitant changes in other factors of the production function and, perhaps, even in exogenous environmental variables. Thus, the holistic systems approach views mechanized agricultural technology as a package of inputs and changes in mechanization as changes in the mix of input variables, usually accompanied by higher production costs to be offset, hopefully, by higher levels of agricultural productivity. Environmental variables must change concomitantly with changes in the production function in order to sustain new forms of mechanized technology.

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Mechanized Agricultural Technology in the Production Function

Mechanized agricultural technology embraces combinations of capital, technical knowledge, and individual competency which are introduced by new or modified variables into the production function and which also cause the function itself to change. The introduction of new components into the production function requires increases in fixed and operating capital, additional skills to be learned by labor and by those responsible for the management of the productive processes represented by the production function. This process, occurring through time, is referred to as technological improvement[1] or more generally as technical progress. Technical progress together with capital formation are considered to be the two important causes of economic development.[2]

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[1]Evsey D. Domar, Essays in the Theory of Economic Growth (New York: Oxford University Press, 1957), pp. 59-60.

[2]"Technical progress, or advance in the state of technical knowledge, consists of the inventions of new methods or new products, that is, the creation of new mental constructs, and the introduction of these constructs into the processes of production in a society. The term 'innovation' is commonly used to refer to the second step.

". . . Capital formation is the use of productive resources for the construction of added capital equipment. Capital formation without technical progress is the creation of added capital embodying methods previously known.

"Innovation and capital formation overlap. Some innovation consists of reorganization of the productive process without any change whatever in the capital

In terms of the three factor production function, capital and technical progress act in concert through time: the former either modifies existing inputs or introduces new inputs, the latter modifies the nature of the function. On the one hand, this concerted action substitutes for or complements labor and land inputs; on the other hand the action can conceivably be neutral, neither substituting nor complementing but raising the productivity of all factors in equal proportion.

Changes in levels of mechanization are appropriately accompanied by other changes in the input mix, and quality of inputs. Thus, the form of production function which can be operated in microanalyses is one in which the quality of inputs is being changed as increasing quantities of capital are added to the form of mechanized technology and accompanying improvements. The general form of function is required to be unique at a given time period (t): $y_t = f_t\ (x_{1_t}, x_{2_t}, \ldots, x_{n_t})$. This function can be modified so that the improvements to each input are explicitly

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equipment used. And innovation often occurs without net capital formation, through replacing worn-out capital instruments with a more efficient one that constitutes no more capital than the old one.

"On the other hand, capital formation may consist of the construction of added units of a type of equipment already known ('capital widening'). Almost no innovation is involved. One can also think of capital deepening without much innovation: the introduction of pieces of equipment already known but not previously used because not enough capital was available." Everett E. Hagen, The Economics of Development (Homewood, Ill.: Richard Irwin, Inc., 1968), pp. 29-30.

introduced as a component of each exogenous variable, the change in quality being represented by the amount of added capital in place of the time subscript:

$$y_t = f_{t,k}[(x_1 + k_1), (x_2 + k_2), \ldots, (x_n + k_n)].$$ [1]

In this form of function, new kinds of capital carrying new technologies are represented by the k_is. Improvements in technical competency of labor and management are reflected in changing values for the function's parameters; these changes occur both through time and with respect to the new kinds of capital introduced into the function.[2]

Substitutability or complementarity between productive factors becomes an important consideration in the mechanization of Ethiopian agriculture because of general concern to expand labor employment. However, unless inputs are perfect complements, some degree of substitutability exists between all factors in the production function. The extent to which substitution takes place depends on technical conditions of the production function, changes in the relative prices of resources, and changes in product prices.

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[1] An accounting problem will arise if this form of function is made operational. As old equipment is replaced and other improved inputs are used, the distinction between the quantity x_i and its corresponding k_i will become increasingly difficult.

[2] The k_is may be considered as efficiency coefficients in which case the function would become: $y_t = f_{t,k}[(x_i k_i), (x_2 k_2), \ldots, (x_n k_n)]$.

The mechanization process, viewed as a means of introducing amounts of capital into the production function, shifts the level of output to a higher isoquant. This shift is accompanied by changes in the relative proportions of component variables in the production function and, therefore, consists of a combination of two effects: output effect and substitution effect. Output effect shows the change in quantities of inputs employed when the level of output shifts, assuming relative input prices are unchanged; substitution effect shows the change in quantities of inputs employed when relative input prices change, assuming output is unchanged.

These changes in the production function and in inputs take place over time. Therefore, analytical procedures are required to facilitate quantitative measurement of these changes and assessment of their likely effect on national well-being. Both financial and non-financial data are required. Budget models provide a series of financial accounts through time and corresponding non-financial data, both based on a given set of initiating assumptions. Certain non-financial data are expressed in monetary terms, e.g., revenue per unit of labor which is a measure of labor productivity, measured in dollars or in indices when change through time is measured; other non-financial data are expressed in non-monetary terms, e.g., level of labor requirements which are measured in labor units or in indices through time. Research techniques, discussed below, provide procedures for collection, simulation, generation, and analyses of appropriate data. Evaluation criteria are used to measure both financial and non-financial data which constitute different parts of economic analysis.

Selection of Cases

Research conducted in the course of the Mechanization Study afforded detailed information from a number of special study sites in Ethiopia. These cases were among the best available sources of data within their respective agricultural systems. Four of these cases were selected for economic analysis in this thesis: the overriding criterion of selection was commercial viability.

Commercial Viability

It has been established above that in this thesis appropriateness includes both economic and technical interpretations and that commercial viability subsumes appropriateness in its broadest connotation. In the mechanization process, additional production costs have to be met by increasing agricultural productivity. The selected cases were judged to contain the potential productive capacity for cash crops to meet added costs of appropriate mechanization and, given adequate extension and

institutional facilities, could be developed into, or already are, commercially viable units.

Careful consideration was given to effective demand for the crops which were proposed to be produced in each case. Effective demand is also subsumed under the criterion of commercial viability. During the process of planning agricultural mechanization there has been a general tendency to neglect the importance of the available markets even though substantial increases in output are part of the total plan.

Effective Demand

The major role of agriculture in the development of the Ethiopian economy has already been identified. The need for increased food supplies and increased exports tends to emphasize the key to economic development as lying within the area of agricultural production. Increasing production, however, is only a part of the agricultural development process. Effective demand must also be brought into consideration.

Conceptually, effective demand for food is a function of per capita income, the income elasticity of demand for food, and the population.[1] In an exchange

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[1]Annual rate of increase in effective demand for food over time is:

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economy, production for exchange is equated with the effective demand of the market; non-cash demand for subsistence crops produced on small family farms is not included. The need for increased food production in Africa has been determined on the basis of accepted nutritional standards. Increasing food intake requirements for individuals, however, are translated into effective demand for agricultural produce through increasing cash incomes. It is effective demand, not biological needs as determined by nutritional studies,[1] which stimulates, and can absorb, marketable agricultural production. The food problem is a demand or income as well as a production problem.[2] Increasing effective demand for staple foods depends on both growth in per capita income and the distribution of income.

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p = (annual) rate of growth of population
ε = per capita income elasticity of demand for food
y = (annual) rate of growth in per capita income (GNP)

President's Science Advisory Committee, The World Food Problem, Vol. II (Washington, D.C.: Government Printing Office, 1967), p. 648.

[1]Glenn L. Johnson, "Food Supply, Agricultural and Economic Development," Proceedings, Western Hemisphere Nutrition Congress II, San Juan, Puerto Rico, August 26-29, 1968 (Chicago: American Medical Association, 1969), pp. 51-52.

[2]The problem of "too low income and not of too low production, two different things." Lauchlin Currie, Obstacles to Development (East Lansing: Michigan State University, 1967), p. 40.

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Expansion in agricultural exports as a means of earning foreign exchange, and increasing the production of import substitutes as a means of saving foreign exchange are essential to the development of the Ethiopian economy. These are also components in the concept of effective demand. Thus, the demand to which the productive capacity of the economy must direct its supply is a function of the effective demand of the indigenous population which includes both subsistence and market demand, world demand for Ethiopian products, domestic demand for imports which the Ethiopian economy could produce.

The significance of effective demand in the macro-framework of agricultural development must not be neglected. Changes of certain technical inputs in the productive processes are only part of the overall economic considerations. Planning the mechanization of productive processes without also giving consideration to resultant increases in production and demand which exist for the product becomes a self-defeating exercise. In the process of national development, commercialization of the agricultural sector and widening the distribution of income among potential consumers must be concomitant processes. Mechanization of the productive processes involves the farmer in higher production costs which have to be met out of increases in income; raising agricultural productivity through appropriate mechanized technology increases production and the need for adequate markets

for the disposal of these surpluses. If effective demand is neglected, a proposed program of mechanization may very quickly encounter problems of surplus production. The outcome will be to declare the scheme a failure when, in fact, the scheme itself may have been technically sound whereas planning may have been too limited in perception.

Economic policies both domestic and international[1] may be introduced to influence the level and rate of increase of effective demand. The importance of effective demand in agricultural development suggests that priorities to product development must be placed on an individual commodity basis. Commodities with low or slowly growing effective demand, or for which the demand is not expressed through cash exchange in the market, receive low priorities. Thus, staple food commodities and nutritionally superior foods used in local diets are given low priority until increasing farm incomes in turn can generate increased effective demand for staples. In the light of

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[1]"Steps [domestic policies] which can be taken by some less developed countries to expand effective per capita demand include: increasing per capita farm incomes by creating more favourable farm policies and investment opportunities in export and import substitution crops; redistributing income to the poor; nutrition education and lowering the cost of producing food and feed grains.

"External approaches to increasing effective demand for a country's agricultural products include: reducing tariffs, duties, etc., to increase trade among less developed countries; reducing tariffs and duties in developed countries on imports from less developed countries, especially on the partially and fully processed commodities and aggressively searching for new markets . . . " Carl K. Eicher, "Production is not Sacred," Ceres--The FAO Review, II, No. 3 (May-June, 1969), p. 39.

effective demand high priority is given to developing production of export and domestic cash crops.[1]

The importance of effective demand also bears on the selection of cases for a study of agricultural mechanization. Ideally, economic research studies on selected commodities should be conducted to determine the nature of effective demand and the potential future demand in domestic and foreign markets. In this thesis, crops for possible mechanization or improved mechanization of the productive processes were selected with due consideration for expansion in production and related effective demand. In both cases, Agnale Village and Chilalo Awraja, where substantial proportions of resources are devoted to producing subsistence crops, a major objective of the budget models is to improve efficiency of production for required quantities of subsistence crops; following these budget adjustments, increasing amounts of resources remaining unused in producing staples are employed to produce increasing amounts of cash crops.

Research Techniques

The first two phases of research were field observations of selected cases and the preparation of production data from the initial observations. The two following phases were data generation (preparation of

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[1] *Ibid.*, p. 38.

budget models) for each case and analyses of generated data. Research techniques and their employment in this thesis are discussed in greater detail in Chapter IV.

Case Studies: Methodological Phases I and II

Four case studies depict typical agricultural systems in Ethiopia which neither represent all the agricultural systems nor completely represent the single category to which each belongs. Rather, the selected case is typical of the agricultural system in its own particular area of Ethiopia. The four cases depict: hand-powered agriculture (Angale Village), in which all tools are operated by human power; transitional animal-powered agriculture (Chilalo Awraja), in which principal implements are operated by oxen although hand-tools are also used and there are opportunities in the area for utilizing tractor power; engine-powered commercial agriculture (Setit-Humera), in which individual farmers are engaged in relatively large-scale cash crop agriculture using tractors along with manual labor; engine-powered plantation agriculture (Tendaho Plantations), in which a large-scale plantation produces a single cash crop using many tractors and large amounts of manual labor.

Field observations provided initial situations for each case study from which budget models have been developed by selecting an appropriate form of mechanized

technology. This is the point of discernment at which the criterion of appropriateness must be exercised with careful judgment.

Data Generation: Methodological Phase III

Without actual observations through time, a synthetic technique is required to generate data. Two alternatives are available: budgeting and linear programming (along with variants of integer and recursive programming). The number of alternative production processes are relatively restricted; production possibilities for a maximum of two strategies (alternative forms or intensity of mechanization) have been investigated in selected case. Also, the agricultural systems under investigation tend to be restricted in the number of crop possibilities either to crops required for subsistence and a limited number of cash crops or, in the commercial operations, to a few relatively profitable crops. Hence, with limited alternatives linear programming tends to be a relatively inefficient technique.[1]

In the maximization (or minimization) procedure employed in the linear programming technique, an objective function is necessary to determine an optimum solution. Determination of an objective function at the current

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[1]Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames: The Iowa State University Press, 1958), pp. 3-4.

state of knowledge of productive systems in Ethiopia is likely to be as elusive as determination of a production function. Furthermore, maximization procedures may introduce additional unrealities into the sets of assumptions for the cases. At present levels of development, commercially-minded farmers employ simple rules of thumb for increasing net returns based on profitability of the immediate previous year's cropping. These procedures can be incorporated into budget models without elaborate requirements for maximization. Currently, both commercial and subsistence farmers are more likely to follow extension advisors' guidance, as relevant technical information becomes available, without following an intensive procedure of manipulating resources in order to realize optimal returns from a wide range of alternative crops and processes. Thus, the full farm budgeting technique was selected as the appropriate means for data generation.

Having selected an appropriate form of mechanized technology, budget models for each system were prepared on the basis of available technical and agronomic information. In the first instance a planning horizon of 10 years was selected, later 20 year approximations were also investigated. The basic data which describe these four agricultural systems in the initiating year (t=0) in which the field observations were conducted and the data generated by the budgeting procedure are recorded in four appendices, A to D.

Data Analyses: Methodological Phase IV

Analyses in phases I, II, and III are technical and financial. In phase IV, the data generated by these procedures are to be examined from the broader viewpoint of development in the context of the Ethiopian economy. Two considerations are important in selection of appropriate analytical criteria. The first consideration is the necessity to appraise the feasibility of mechanizing the agricultural processes by analyzing the generated financial data. Benefit-cost analyses have been employed for this consideration. These analyses determine net present values, payback period, internal rates of return, benefit-cost ratios, and modified benefit-cost ratios.

The second consideration is the necessity to appraise the synthesized agricultural systems represented by the budget models in relation to those objectives for economic development adopted by the policy-makers in the five-year development plans. In the Third Five-Year Development Plan "agricultural policy is designed primarily to deal with two great problems which beset Ethiopia--the problem of production and the problem of the peasantry."[1] Certain specified objectives, discussed in detail in Chapter IV, are employed as evaluation

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[1]Imperial Ethiopian Government, Third Five-Year Development Plan, 1961-1965 E.C. (1968-1973) (Addis Abeba: Haile Selassie I Printing Press, 1968), pp. 189-90.

criteria for non-financial aspects of the case studies. Trends in these aspects are examined by computing index numbers at selected points in time over the period of the budget model.

CHAPTER II

THE ETHIOPIAN SITUATION: NATURAL RESOURCES, PEOPLES, NATIONAL ECONOMY

The previous chapter served to introduce the subject of agricultural mechanization and its place both operationally and conceptually in the development of a specific economy. The purpose of this chapter is to provide the context for the ensuing discussion and analyses. Obviously, the Ethiopian situation embraces a great diversity of factual materials and interpretations of Ethiopian socio-economic life: past, present, and anticipations for the future. The principal sections of the chapter are focused, howbeit summarily, on Ethiopia's natural resources, her peoples, and the structure of her economy.

Natural Resources

Physical Environment

Geography

Ethiopia occupies the eastern area of the African continent known as the Horn of Africa; the Empire stretches from latitude 3 degrees to 18 degrees North and lies between longitudes 33 and 48 degrees East. The total area of 1,221,900 square kilometers is shown in Figure 1 to be roughly triangular with Kenya, Somalia, the Territory of Afars and Issas, and the Sudan being contiguous countries.[1]

The physiography of Ethiopia is characterized by the massive highland complex of mountains and plateaux transversed from the northeast to southwest extremities by the deep Rift Valley, most of the lowlands lie around the Empire's periphery. The highest point of the highland _massif_ is Ras Dashen of the Simien Range in the province of Begemdir and Simen,[2] rising to 4,543 meters; there are 24 other major peaks of over 3,500 meters throughout Ethiopia.[3] The _massif_ is formed out of crystalline rocks covered with thick sedimentations of limestone, sandstone, and volcanic lava. The Rift Valley (floor elevation about 1,600 meters) forms a natural channel between the Red Sea and the system of East African

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[1]Kifle-Mariam Zerom, _The Resources and Economy of Ethiopia_, Report No. 13, SRI Project 6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, February, 1969), p. 9.

[2]Hereafter referred to as Begemdir.

[3]Imperial Ethiopian Government, _Statistical Abstract, 1967 and 1968_ (Addis Abeba: Central Statistical Office, 1969), p. 12.

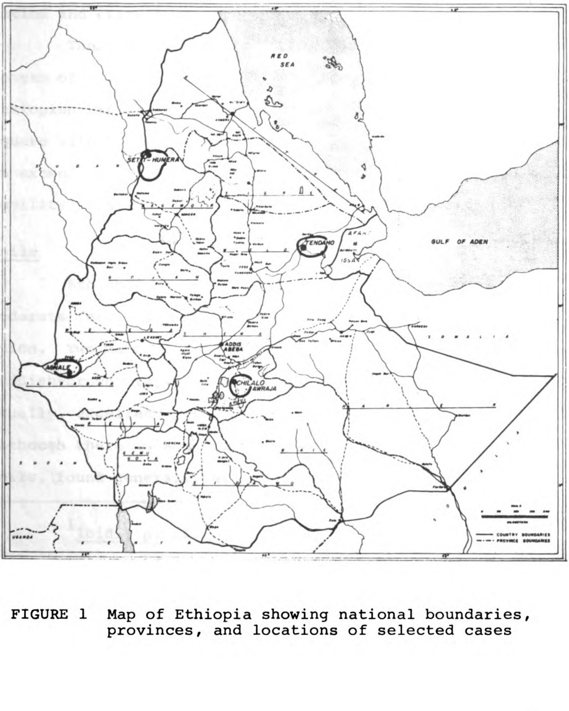

FIGURE 1 Map of Ethiopia showing national boundaries, provinces, and locations of selected cases

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lakes. Small volcanoes, hot springs, and deep gorges in the region are contemporary evidences of former volcanic action and current geological instability.

There are nine major river systems with a total length of 5,785 kilometers within the territory of the Ethiopian Empire, and 11 major lakes totalling 7,023 square kilometers.[1] These geographical features depict an exceedingly rugged terrain in which human geographical mobility is severely restricted by physical obstacles.[2]

Soils

Ethiopian soils are considered to be only of moderate fertility although there is much regional variation. Two main soil types are distinguished: red to reddish-brown clayey loams which have good fertility usually, excellent permeability and air-water ratio although there is some phosphorous deficiency;[3] black soils, found generally at lower elevations, which have

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[1] Ibid., p. 11.

[2] Ethiopia is described by Huffnagel as the "water tower of northeastern Africa." A description of the river and lake systems of Ethiopia is contained in chapter VIII, "Hydrography." H. P. Huffnagel, Agriculture in Ethiopia (Rome: Food and Agriculture Organization of the United Nations, 1961), pp. 51-56.

[3] Further discussions on soils are included in the Appendices A to D. Also Donahue's soil analyses for each Ethiopian study site are included in the Mechanization Study report. Kline, et al., op. cit., Pt. II, pp. 38-46.

poorer fertility, tending to dry out quickly and crack badly.[1]

Soil fertility of Ethiopia has been grouped into three categories based on a map prepared by the Committee on Regional Aspects of National Planning in Ethiopia: useless to poor; average to partly good; good to excellent. Useless to poor soils are found in the northeastern, eastern, southern, and southeastern regions of Ethiopia; average to partly good soils occur in northern crystalline highlands, the central and southern highland regions; good to excellent soils are located in the central, eastern, and southeastern regions.[2]

It must be noted that Ethiopia's major soil problems, especially in the highlands, are erosion on the slopes and drainage in collecting areas. Large areas of fertile land are lost annually.

Climate

Although Ethiopia lies within the Tropics of Cancer and Capricorn the prevailing climate cannot be described as tropical: altitude is an important factor

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[1]Huffnagel, op. cit., p. 37. Huffnagel gives a detailed description of the nature and behavior of Ethiopian soils under the following geological areas: Central Highlands, Northern Crystalline Highlands, Rift Valley, Eastern Highlands, East and Southeast Ethiopia. Ibid., pp. 38-50.

[2]Zerom, op. cit., pp. 12-13.

in determining the temperature.[1] Thus, the Ethiopian climate may be classified into climatic zones according to elevation as shown in Table 1.

TABLE 1 Classification of climate according to altitude and temperature, Ethiopia

Climatic zone	Altitude	Average annual temperature
	meters	degrees centigrade
Alpine	Above 3,500	14
Temperate	2,400-3,500	16
Subtropical	1,800-2,400	22
Tropical	Below 1,800	26
Desert	Below 1,800[a]	30

[a]Desert zones are really a subgroup of the tropical zones in which environmental conditions cause a higher average annual temperature.

Source: Zerom, *op. cit.*, p. 15.

Marked variations in temperature occur at elevations above 2,000 meters and frosts also occur in most years. Day length (average 12 1/2 hours) varies little between seasons. These factors tend to have affected

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[1]"Although there is no common agreement among scientists regarding the elevation ranges within the Equatorial Belt that are considered 'Tropical' several criteria have been advanced. These include:

1. Areas free of frost.
2. Areas with climates favorable to the production of cold-sensitive perennial crops such as sugarcane, banana, and coconut.
3. Areas too low in elevation for production of wheat."

Kline, *et al.*, *op. cit.*, p. xvii.

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Less variation is observed in daily temperatures at lower elevations and frosts seldom occur. Lower areas are often excellent for agricultural production, growing crops throughout the year. However, rainfall tends to decrease at lower altitudes, thus in many of the lower areas agriculture is less well developed in contrast to the highlands where annual precipitation is satisfactory.

In general there are two rainy seasons, although there is considerable regional variation from the general pattern. The rainy seasons are: kiremt occurring July through September, the time of the "big rain" (tili'k zenab); bulg occurring February through April, the time of the "small rain" (tini'sh zenab). In addition to this seasonal pattern, much moisture, evaporated from the Red Sea during the dry season, October through February, is precipitated on the face of the Eastern Escarpment, giving this area a completely different rainfall pattern.

The rugged physiography of Ethiopia greatly affects the distribution of rainfall and accounts for a wide variety of micro-climatic conditions. The climatic characteristics of the country can be classified into 10 regions as shown in Figure 2. Only those regions in which the selected case studies are found are considered in any detail here. The data recorded in Table 2 summarize the climatic conditions for all 10 regions.

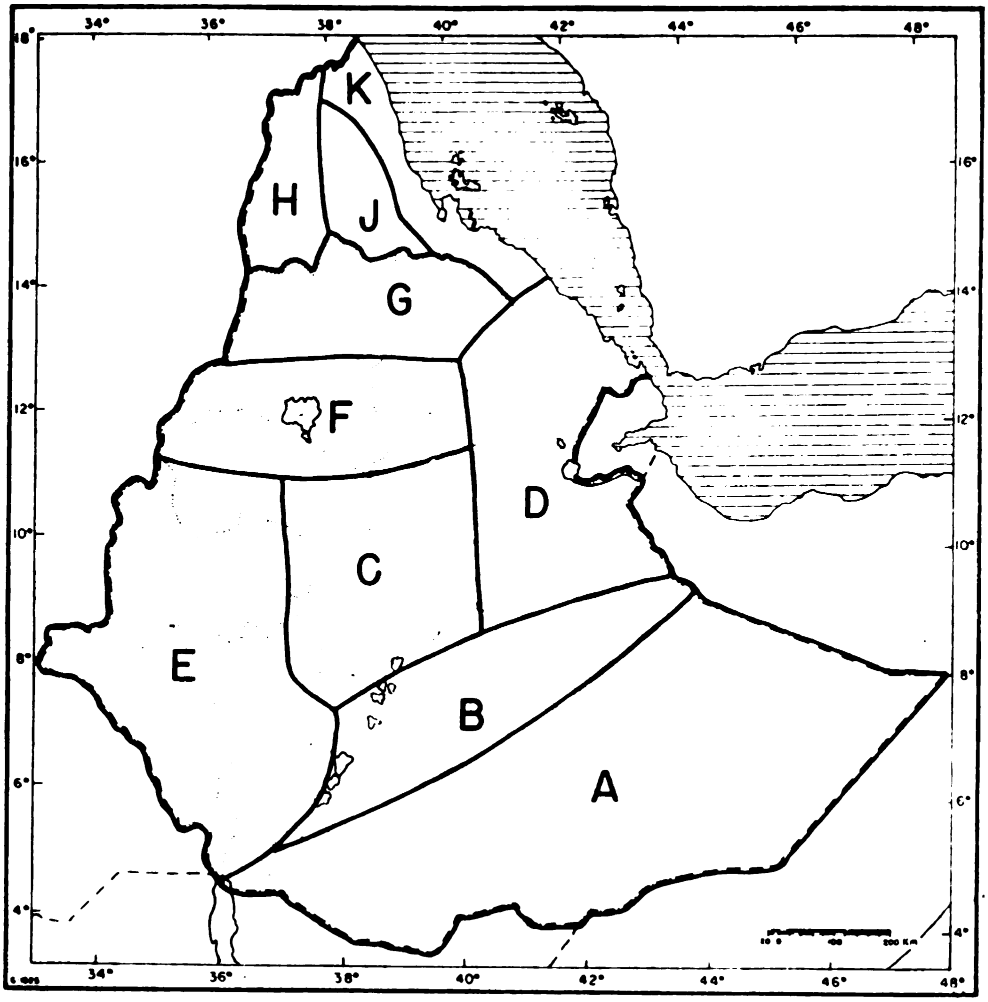

FIGURE 2 Climatic regions of Ethiopia.

Source: Huffnagel, op. cit., p. 60.

TABLE 2 Climatic regions, Ethiopia: altitude, position, mean temperature range, and mean annual rainfall

TABLE 2 Climatic regions, Ethiopia: altitude, position, mean temperature range, and mean annual rainfall

Region	Station	Record period	Altitude	Position		Mean temperature range			Mean annual rainfall
				North	East	Monthly	Maximum	Minimum	
		years[a]	meters			-----degrees	centigrade------		millimeters
A	Neghellic	1952-57	1,430	05°19'	39°40'	n.a.[b]	n.a.	n.a.	491.3
B	Goba	1953-57	2,727	07°10'	40°00'	n.a.	n.a.	n.a.	664.4
C	Addis Abeba	1948-57	2,408	09°02'	38°45'	15.5-18.1	20.2-25.9	6.8-10.8	1228.8
D	Aseb	1949-57	11	13°01'	42°43'	n.a.	27.9-38.0	22.1-30.2	66.4[c]
E	Gore	1953-57	2,005	08°10'	35°33'	17.6-20.0	20.3-26.0	12.1-13.7	2179.3
F	Gonder	1953-57	2,121	12°36'	37°29'	17.2-21.2	21.5-28.9	9.5-15.5	1292.0
G	Maichaw	1953-57	2,300	12°44'	39°16'	14.5-19.8	24.8-30.0	4.3-12.4	832.6[d]
H	Agordat	1949-57	633	15°33'	37°53'	n.a.	32.0-39.9	14.7-23.8	328.5
J	Asmera	1949-57	2,325	15°17'	38°55'	n.a.	21.2-25.6	6.4-12.1	536.0
K	Mitsiwa	1949-57	5	15°36'	39°28'	n.a.	28.4-38.3	19.4-27.2	216.1

[a]Gregorian calendar is used throughout this thesis. [b]Not available.

[c]Rainfall slightly atypical due to December rainfall maximum which occurs only in coastal areas.

[d]Not quite typical of region due to close proximity to the Escarpment.

Source: Huffnagel, *op. cit.*, pp. 64-75.

The climatic regions in which the case studies are located (in parenthesis) are the following:

1. Region E (Agnale Village: Appendix A) includes the lower areas of Gemu Gofa, Kefa, Welo, Gojam, and Ilubabor provinces. This region is the wettest in the Empire. Maximum rainfall occurs between June and September although precipitation is normal for every month; the minimum rainfall period is November to February.
2. Region C (Chilalo Awraja: Appendix B) includes Shewa province and the central highland massif. Rainfall occurs in the two distinct periods with a continuous dry period from October to February. During the big rains there is seldom a dry period and precipitation is intense. Humidity is high during both rainy seasons. Toward the end of the dry period humidity is low and frosts occur at night. This is also a period of daytime winds.
3. Region G (Setit-Humera: Appendix C) includes most of Tigre and northern Begemdir provinces. Rainfall is light and confined to the period July to September. The period from October to February is almost completely dry with high evaporation. This region is similar to Region

D but, because it lies on higher ground, temperatures are lower.

4. Region D (Tendaho Plantations: Appendix D) includes the low-lying land of Welo, Tigre, and Eritrea provinces east of the Eastern Escarpment. Some desert zone is included; the only extensive rains occur during July to September. The period between October and March is one of low humidity and strong winds.

Other Natural Resources

Fuel and Power

Wood from cedar and later eucalytus forests, has been the main fuel until recently; now the consumption of petroleum fuels and gas is increasing. Success in oil exploration will increase Ethiopia's economic self-sufficiency and export potential. Ethiopia's coastal area has yielded large petroleum and gas reserves.

The hydro-electrical potential of Ethiopia's major river systems is considerable. Theoretically, the annual available potential of eight major river basins is 143,481 millions of kilowatt hours.[1]

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[1]Zerom, *op. cit.*, pp. 66-69.

Mineral Ores

Ethiopia has a number of deposits of precious metals, iron ore, ores of non-ferrous metals, and non-metals. Exploitation of these resources so far has been at a very low level. At present only manganese ore, marine salt, and feldspar are exported. Fertilizers, glass, pottery, iron, lead, copper, and other metals are being imported.[1]

Agriculture, Fisheries, and Forestry

The use of agricultural resources forms the largest contribution to the Empire's gross domestic product. Agriculture is the main occupation of the Ethiopian people and the principal source of foreign exchange resources.

There is also an abundance of fish. In addition to the Red Sea, the lakes and rivers of Ethiopia are abundant in commercially useful fish. However, no commercial exploitation of this resource has taken place yet, nor does fish make much contribution to the Ethiopian diet.[2]

A considerable amount of deforestation has occurred during Ethiopia's history. Indigenous forests of olive, cedar, juniper, and various pines have been "ruthlessly" burned leading to an acute shortage of fuel and building timber during the nineteenth century. The eucalyptus forests, established toward the turn of the last century

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[1] *Ibid.*, pp. 74-77. [2] *Ibid.*, p. 48.

on the initiative of Emperor Menelik II now meet major fuel demands.[1] Today there remain some five million hectares of forest. Necessary legal measures to prohibit further destruction and to foster reforestation have been initiated but the potential of a forestry industry has not yet been exploited commercially.[2]

Peoples of Ethiopia

No complete population census has yet been conducted in Ethiopia. Data recorded in Table 3 are estimates for 1967-68 obtained from the National Sample Surveys. The estimated population of Ethiopia is 24 millions of which 8.1 per cent live in urban communities.

Population distribution throughout the provinces is uneven due to the prevalence of malaria in the lowlands causing heavy concentrations of population in the highlands. A high proportion of the total population consists of children and adolescents. One-third of the population is under 10 years of age, 45 per cent is under 15 and only 5 per cent is older than 60.[3]

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[1]Richard Pankhurst, Economic History of Ethiopia, 1800-1935 (Addis Abeba: Haile Selassie I University Press, 1968), pp. 243-47.

[2]Ibid., pp. 51-52.

[3]Eli Ginzberg and Herbert A. Smith, Manpower Strategy for Developing Countries: Lessons from Ethiopia (New York: Columbia University Press, 1967), pp. 21-23.

TABLE 3 Area, estimated population, and population density by province, Ethiopia, 1967

Province	Area	Population	Urban fraction of total	Population density
	millions of hectares	numbers in 1,000s	per cent	persons per square kilometer
Arusi	2.35	1,110.8	3.7	47
Bale	12.46	159.8	12.5	1
Begemdir	7.42	1,348.4	5.2	18
Eritrea	11.76	1,589.4	16.7	14
Gemu Gofa	3.95	840.5	2.6	21
Gojam	6.16	1,576.1	4.4	26
Harer	25.97	3,341.7	4.6	13
Ilubabor	4.74	663.2	3.8	14
Kefa	5.46	688.4	7.7	13
Shewa	8.52	3,970.3[a]	21.5	39
Sidama	11.73	1,521.9	6.0	13
Tigre	6.59	2,307.3	4.6	35
Welega	7.12	1,429.9	3.8	20
Welo	7.94	3,119.7	3.2	39
Total	122.19	23,667.4	8.1	19

[a]Includes Addis Abeba: 644.2 thousand people in .02 millions of hectares (3,221 persons per square kilometer).

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, p. 26.

> Foremost among the peoples of Ethiopia are the Amhara and the Tigreans. Since the formation of the Ethiopian state they have been the kernel of Ethiopia; they made its history and determined its Christian character. Together, they are more numerous than any other single group within the Empire.[1]

Both these groups of people live in settled agricultural communities.

The Galla (Omoro) people, only slightly less numerous than the other two groups together, were originally pastoralists, now many are agriculturalists. Moving into Ethiopia probably from the corner of the Horn by conquest during the sixteenth century,[2] the Galla of Shewa have embraced Christianity; those settling in parts of Arusi and Kefa embraced Islam, others remained pagan. Amhara, Tigreans, and Galla account for the majority of Ethiopian people. In addition there are the Afar (Danakils), Moslem pastoralists who inhabit the hot desert plains. These four Ethiopian groups are Cushitic people, descendants of a union of Hamitic and Semitic races.

Small groups of Nilotic peoples inhabit the western extremities of the Empire. They form no integral part of the life and civilization of Ethiopia. The Nuer and Anuaks live in the southwest; the Barea and Kunama along the western border of Eritrea.[3]

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[1]Huffnagel, op. cit., p. 15.

[2]Edward Ullendorff, The Ethiopians: An Introduction to Country and People (London: Oxford University Press, 1960), p. 41.

[3]Ibid., pp. 44-46.

Illiteracy is a continuing problem among the people of Ethiopia; less than 10 per cent of eligible children are in grades one to six, less than 2 per cent attend higher grades. Proportions are lower in rural areas.

Employment in manufacturing has grown at an annual rate of 15 per cent indicating that about 100,000 people will be employed in this sector by the early 1970s. However, by the end of the century, three-quarters of the labor force will still be engaged in agriculture.[1]

Structure of the Ethiopian Economy

General Status of the Economy

Ethiopia has a mixed economy. Government effort is not restricted to social development. Indeed, it is anticipated that the private sector is likely to expand only "at a very modest rate."[2] The single most important determinant of the future demand for trained manpower will be the rate of growth in government expenditures; efficiency in both government and quasi-government corporations "holds

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[1]Clarence J. Miller, William L. K. Schwartz, Willis W. Shaner, Kifle-Mariam Zerom, *Development of Agriculture and Agro-Industry in Ethiopia: A Proposed Program of Research and Planning Studies*, Phase I Report, SRI Project-IU-6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, October, 1967), p. 10.

[2]Ginzberg and Smith, *op. cit.*, p. 86.

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the key to progress of the economy and the society."[1] However, agriculture is the mainstay of the population, thus much of the government's endeavors must be directed toward the agricultural sector.

Agriculture

The data recorded in Table 4 show that agricultural production exceeded 55 per cent of GDP (at constant factor cost) from 1961 to 1967. However, agriculture's relative contribution to GDP declined steadily from 64.8 per cent at the beginning of this period. Per capita GDP from agriculture is reported to

> . . . have increased only fractionally. In fact, since 80 percent of all agricultural output is for farm family subsistence, the accuracy of even this increase in per capita output is questionable. It is possible that Ethiopia's agricultural sector has no more than kept pace with population growth.[2]

1) Land Use

Data presented in Table 5 are rough estimates of the major land uses. There are large areas of apparently productive land which are used either for nomadic grazing or not at all. The use of some areas is limited because of inaccessibility, lack of accessible water supply, or the prevalence of disease vectors, mainly mosquito and tsetse fly.

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[1] *Ibid.*, pp. 35-36.

[2] Miller, *et al.*, *Development of Agriculture . . .*, *Phase I Report*, p. 15.

TABLE 4 Gross domestic product at constant factor cost (1961 prices) and distribution of gross domestic product by industry of origin, Ethiopia, 1961-67

GDP item and sector	1961	1962	1963	1964	1965	1966	1967

TABLE 4 Gross domestic product at constant factor cost (1961 prices) and distribution of gross domestic product by industry of origin, Ethiopia, 1961-67

GDP item and sector	1961	1962	1963	1964	1965	1966		1967	
	---------millions of Ethiopian dollars[a]						--------millions--------		
							U.S.$	E.$	U.S.$[b]
Gross domestic product at constant factor cost	2,323.3	2,427.3	2,508.8	2,631.1	2,726.6	2,909.0	1,163.3	3,071.7	1,228.7
	----------per cent----------								
Agriculture	64.8	63.1	62.3	60.7	58.6	56.7		55.6	
Farming	61.8	60.1	59.4	57.8	55.8	54.0		52.8	
Forestry	2.8	2.8	2.8	2.7	2.6	2.5		2.6	
Hunting	0.1	0.1	0.1	0.1	0.1	0.1		0.1	
Fishing	0.1	0.1	0.1	0.1	0.1	0.1		0.1	
Mining and manufacturing	12.3	12.9	13.1	13.9	14.5	15.4		16.9	
Mining and quarrying	0.2	0.1	0.2	0.2	0.3	0.3		0.3	
Manufacturing	1.9	2.1	2.3	2.6	2.9	3.2		3.8	
Handicraft and small scale industry	4.2	4.2	4.1	4.5	4.6	4.7		4.8	
Building and construction	5.6	6.0	5.9	5.9	6.0	6.4		7.1	
Electricity and water	0.4	0.5	0.6	0.7	0.7	0.8		0.9	
Commerce and transport	9.0	9.5	10.0	10.8	11.4	12.0		11.6	
Other services	13.9	14.5	14.6	14.6	15.5	15.9		15.9	
Total	100.0	100.0	100.0	100.0	100.0	100.0		100.0	

[a] E$ 1.00 = U.S.$ 0.40.

[b] Values are given in U.S. dollars also since all analyses in this thesis are computed in U.S. dollars.

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, p. 132.

TABLE 5 La

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TABLE 5 Land use, Ethiopia, 1967-68

Use	Area	Distribution		
	millions of hectares	------per cent-------		
Crops	9.99	78.7		
Fallow	2.00	15.8		
Fruits and stimulants	.70	5.5		
Total cultivated	12.69	100.0	15.1	
Pasture	66.24		78.7	
Swamp	5.18		6.2	
Total agricultural	84.11		100.0	68.8
Forest	8.78			7.2
Barren or built-up	17.21			14.1
Water and water courses	12.09			9.9
Total	122.19			100.0

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, p. 11.

Nevertheless, there are thousands of hectares which are accessible to markets and not subject to health problems that are used at only very low levels of farming intensity. Thus, there are substantial opportunities both for increasing the intensity of farming on presently cultivated lands and for opening up new lands to specialized cropping activities and to systems of mixed farming incorporating both crops and livestock.[1]

2) Cropping Patterns

Estimated cropping patterns are given in Table 6 for the seasons 1963/64-66/67. By far the largest proportion of land is devoted to the production of cereals.

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[1] Ibid., p. 16.

TABLE 6 Estimated area and production for major crops, Ethiopia, 1963/64-66/67

Crop	1963/64		1964/65		1965/66		1966/67	
	Area	Production	Area	Production	Area	Production	Area	Production
	1,000 ha.	1,000 m. tons	1,000 ha.	1,000 m. tons	1,000 ha.	1,000 m. tons	1,000 ha.	1,000 m. tons
Cereals	6,812.1	4,987.9	6,880.9	5,099.0	6,942.9	5,206.1	7,061.4	5,320.1
Barley	1,636.0	1,325.2	1,643.8	1,347.9	1,652.6	1,371.7	1,672.8	1,398.9
Maize	790.5	766.8	800.4	788.4	812.1	812.1	820.2	826.6
Sorghum	1,063.8	853.3	1,071.2	867.7	1,081.7	887.0	1,129.5	922.1
Teff	2,108.0	1,243.7	2,110.0	1,255.5	2,111.6	1,267.0	2,132.7	1,285.5
Wheat	920.8	653.8	962.3	692.9	988.6	721.7	1,008.4	738.9
Other[a]	293.0	145.1	293.2	146.6	296.3	146.6	297.8	148.1
Ensete	178.5	424.9	181.0	432.1	183.4	440.2	187.1	449.0
Fibers	211.0	16.2	219.9	17.5	226.5	21.6	239.7	22.8
Cotton	30.0	2.4	35.0	3.4	40.0	7.2	49.4	8.2
Ensete	178.5	12.0	181.0	12.0	183.4	12.2	187.1	12.4
Sisal	2.5	1.8	3.0	2.1	3.1	2.2	3.2	2.2
Oilseeds	690.0	361.6	703.1	367.8	725.5	391.7	761.5	405.8
Castor bean	21.0	10.5	21.0	10.5	21.3	10.6	21.3	10.9
Cotton seed	30.0	5.1	34.0	6.8	40.0	14.4	49.4	16.5
Groundnut	34.0	17.0	35.0	17.5	35.0	17.5	36.3	18.5
Linseed	106.0	53.0	108.3	54.1	110.8	55.4	113.0	56.5
Neug	355.0	213.0	358.0	214.8	367.6	227.9	375.0	232.5
Rapeseed	13.0	5.2	13.3	5.3	13.3	5.3	13.8	5.5
Safflower	53.5	26.8	54.5	27.2	56.0	28.0	57.2	28.6
Sesame	77.5	31.0	79.0	31.6	81.5	32.6	95.5	36.8

Pulses	774.5	549.8	785.7	560.7	794.5	576.1	809.2	586.6
Haricot bean	88.0	61.6	89.0	63.2	90.0	64.8	91.0	66.4
Horse bean	118.0	106.2	124.0	112.8	126.5	116.4	131.4	120.9
Other[b]	568.5	382.0	572.7	384.7	578.0	394.9	586.8	399.3
Coffee	597.0	139.2	603.0	170.4	606.0	140.0	608.0	155.0
Tobacco	2.8	1.4	2.9	1.5	2.9	1.5	2.9	1.5
Sugarcane	5.5	689.0	5.6	728.0	5.9	826.0	5.9	855.0
Fruits and vegetables	394.3	727.3	400.9	740.7	407.4	767.0	413.7	788.5
Other crops[c]	87.5	87.5	89.7	89.7	93.2	93.2	95.2	94.1
Total	9,753.2	7,984.8	9,871.8	8,207.4	9,988.2	8,463.4	10,184.6	8,678.4

[a]Dagusa (millet). [b]Chick-peas, field peas, lentils, fenugreek.

[c]Chat and gesho (stimulants).

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, pp. 44-45.

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3) Livestock

Ethiopia's livestock population is claimed to be the largest in Africa, but statistical accuracy is uncertain. The data in Table 7 show estimates of livestock population and production. At present livestock production is extremely low, calf losses are great, and animals mature slowly. The practice of accumulating livestock, particularly cattle, as a means of storing wealth often results in animals being kept past their optimal marketing age. Livestock production may become an important foreign exchange earner in the future.[1]

4) Agrarian Structure and Lane Tenure

The information on land tenure and agrarian structure is inadequate at present. The Ministry of Land Reform and Administration has conducted surveys of land registration, and classification according to systems of ownership. The source of data recorded in Table 8 is a small sample survey conducted by the Central Statistical Office in which the term "holding" rather than farm was used: a holding was defined "as all land used wholly or

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[1]United Nations, Report of the Exploratory Mission to Ethiopia in Connection with a Possible Agricultural Economic Survey (Rome: Food and Agriculture Organization, 1965), cited in Miller, et al., Development of Agriculture . . ., Phase I Report, p. 18.

TABLE 7 Annual estimated livestock population and production, Ethiopia, 1963/64-66/67

Livestock (and product)	Annual population				Annual production			
	[illegible]	1964/65	1965/66	1966/67	1963/64	1964/65	1965/66	1966/67

TABLE 7 Annual estimated livestock population and production, Ethiopia, 1963/64-66/67

Livestock (and product)	Annual population				Annual production			
	1963/64	1964/65	1965/66	1966/67	1963/64	1964/65	1965/66	1966/67
	------------thousands-------------				----thousands of m. tons-----			
Cattle (beef)	25,269.9	25,424.9	25,603.9	25,782.9	221.2	227.2	234.8	240.0
(milk)					440.0	453.5	465.0	476.7
Sheep (mutton)	11,637.7	11,800.2	11,971.3	12,150.9	40.2	41.5	23.0	44.3
Goats (meat)	10,866.0	10,953.0	11,029.7	11,095.9	44.1	44.6	45.1	46.1
Pigs (port)	11.0	11.5	12.0	12.6	0.7	0.7	0.7	0.8
Horses	1,330.0	1,340.2	1,350.4	1,360.7				
Mules	1,330.0	1,340.2	1,350.4	1,360.7				
Donkeys	3,747.0	3,760.0	3,775.1	3,790.3				
Camels (milk)	945.0	951.2	957.5	963.8	63.8	64.4	65.0	65.6
Poultry (meat)	41,500.0	42,500.0	43,500.4	44,500.0	45.8	46.9	48.7	49.9
(Other meats)					0.1	0.1	0.1	0.1
					----------thousands-----------			
Hides and skins								
Bovine hides					2,717.0	2,719.0	2,787.0	2,765.0
Sheep skins					4,524.0	4,627.0	4,737.0	4,854.0
Goat skins					4,002.0	4,112.0	4,119.0	3,977.0

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, pp. 48 and 50.

TABLE 8 Distribution by size and tenure for farmland (holdings), nine provinces, Ethiopia, 1967-68

TABLE 8 Distribution by size and tenure for farmland (holdings), nine provinces, Ethiopia, 1967-68

Province	Group size in hectares						Average cultivated area per farm	Tenure		
	0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-3.0	3+		Owned	Rented	Part owned/part rented
	per cent						hectares	per cent		
Arusi	8	23	15	14	20	20	1.94	48	45	7
Gojam	27	27	18	12	10	6	1.15	80	13	7
Shewa	23	22	16	11	13	15	1.67	33	51	16
Tigre	45	23	16	5	6	5	1.27	75	7	18
Welo	55	25	11	3	4	2	0.97	60	17	23
Welego	29	36	14	10	7	4	1.27	41	54	5
Gemu Gofa	73	19	4	2	2	-	0.54	53	43	4
Begemdir	40	30	13	9	5	3	1.40	71	18	11
Sidama	73	18	5	2	1	1	0.52	61	37	2

Source: Imperial Ethiopian Government, Provincial Surveys (Addis Abeba: Central Statistical Office, 1967-68), quoted in Zerom, *op. cit.*, p. 27.

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partly for agricultural production and operated by members of one household."[1]

These data show a high proportion of farms too small to be considered adequate for economic development. Similarly, in southern parts of the Empire a high proportion of rented land (usually share-cropping agreements) tends to discourage the adoption of agricultural improvements since additional returns must be shared with the land-owner. In the northern part of the Empire, a higher proportion of farms are owner-operated. Most land, however, is held under family ownership systems and subject to periodic redistribution, thus limiting the incentive to invest.

> Under the existing agrarian structure then, the majority of small farms could not qualify for further development. Because of out-of-date land ownership systems (which in many areas of Ethiopia are not clearly defined) and the lack of security of tenure, the majority of farmers could not qualify for the advancement of credit, even though they possessed the productive capacity to employ such credit efficiently. The ability of the majority of small farmers to accumulate money is negligeable, therefore, they cannot afford to purchase improved seed or other adjuncts to improve production. The reform of the existing agrarian structure--the system of land ownership and the tenancy system--is a prerequisite for the development of Ethiopian agriculture.[2]

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[1]Zerom, op. cit., p. 24.

[2]John L. Fischer, "Agriculture in Ethiopia" (Addis Abeba: USAID/Ethiopia, May, 1967), p. 15. (Mimeographed.)

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Other Industry

The major components of Ethiopia's manufacturing sector of the economy are depicted in Table 9. These data are based on reports from 272 establishments made in 1964/65, 273 in 1965/66, and 395 in 1966/67.[1] Thus, while there is no guarantee that all existing industrial establishments have been included, the data illustrate the relative smallness of the manufacturing sector.

It is not always easy to distinguish between agriculture and agricultural industry. The agricultural sector may be defined "as encompassing the direct product of the farm prior to any off-farm processing,"[2] and the agricultural industry sector as

> . . . (1) the production of goods and services that go into farming and (2) the off the farm processing, handling, or other commercial treatment of agricultural products.[3]

The nature of the Ethiopian economy is such that the definition of the agricultural industry (agro-industry)[4] sector

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[1]Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, p. 57.

[2]Miller, et al., Development of Agriculture . . ., Phase I Report, p. 20.

[3]Ibid.

[4]In the Final Report a further explication of the definition is added: "Agro-industry is defined to mean any step in processing, manufacturing, and distribution that has linkages to agricultural production or agricultural products. While backward or forward integration into farming or industry is accepted by this definition,

TABLE 9 Employment and gross value product by groups of manufacturing industries, Ethiopia, 1964/65-66/67

Industrial group	1964/65		1965/66			1966/67		
	Employees	Gross value product	Employees	Gross value product		Employees	Gross value product	
	numbers	thous. E$	numbers	thous. E$[a]	thous. U.S.$[a]	numbers	thous. E$[a]	thous. U.S.$[a]
Food	18,596	72.3	22,112	80.9	32.3	22,170	113.2	45.3
Beverages	2,136	36.7	2,473	42.0	16.8	2,548	45.8	18.3
Tobacco	451	5.4	1,095	7.3	2.9	489	7.1	2.8
Textiles	15,802	62.6	17,040	79.1	31.6	19,271	103.1	41.2
Leather and shoes	1,892	9.1	2,298	13.0	5.2	2,100	17.4	7.0
Lumber	2,251	5.7	2,147	6.9	2.8	3,026	9.8	3.9
Building and materials (non-metal)	3,102	10.6	3,684	12.7	5.1	4,336	18.1	7.2
Printing and publishing	1,141	5.3	1,403	6.4	2.6	1,499	8.0	3.2
Chemicals	1,400	6.5	1,618	9.3	3.7	2,227	12.4	5.0
Steel, metal, electrical	926	5.5	930	12.2	4.9	1,028	22.2	8.9
Total	47,697	219.7	54,800	269.8	107.9	58,694	357.1	142.8

[a]Values are given in U.S. dollars also since all analyses in this thesis are computed in U.S. dollars.

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, pp. 57-58.

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includes approximately 85 per cent of all manufacturing when measured by employment or by the gross value of the product.[1]

External Trade and Balance of Payments

Details of exports, by major commodity, for the period 1961-67 are given in Table 10. Since the closure of the Suez Canal, an anticipated decline in exports has become apparent in 1967 data. Over five-year periods beginning in 1945[2] increases in the value of exports were: 1945-50, 44 per cent; 1950-55, 78 per cent; 1955-60, 19 per cent; 1960-65, 50 per cent.[3] The basic weakness in Ethiopia's export position shows in heavy dependence on coffee, constituting 50-65 per cent of the total value over the period 1961-66. Details of imports are given in

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no particular level or form of integration is assumed necessary." Clarence J. Miller, Willis W. Shaner, Raymond E. Borton, Development of Agriculture and Agro-Industry: Strategy and Programs, Final Report, SRI Project 6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, December, 1969), p. 4.

[1]Ibid., p. 23.

[2]The exchange rate was fixed at U.S. $0.40 = E$ 1.00 in 1945 and has not changed since.

[3]William L. K. Schwartz, Ethiopia's Export Trade in Major Agricultural Commodities, Report No. 6, SRI Project IU-6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, January, 1969), p. 11.

TABLE 10 Annual value (f.o.b.) of exports by major commodity groups, Ethiopia, 1961-67

Commodity group	Annual value of exports								
	1961	1962	1963	1964	1965	1966		1967[a]	
	thousands of Ethiopian dollars						thousands		
							U.S.$	E.$	U.S.$
Coffee	93,874	107,198	110,935	158,932	188,347	156,044	62,417	139,182	55,673
Oilseeds and cakes	17,374	23,688	31,801	30,130	28,331	26,611	10,644	25,250	10,100
Cereals and pulses	18,027	16,849	16,389	13,982	15,117	21,264	8,505	20,200	8,080
Skins and hides	25,134	24,764	23,449	21,945	23,528	35,647	14,259	27,775	11,110
Meats (canned and frozen)	3,213	1,489	2,503	5,846	7,405	7,329	2,932	6,804	2,721
Live animals and chickens	456	408	1,119	2,349	3,139	2,255	902	3,280	1,312
Other	25,420	21,801	33,253	25,969	17,178	19,953	7,982	27,285	10,914
Re-exports	5,125	3,353	3,961	3,377	6,788	8,418	3,367	2,724	1,090
Total	188,623	199,550	223,410	262,530	289,833	227,521	111,008	252,500	101,000

[a]Estimated on the basis of Zerom's balance of payments, Schwartz's proportions of value, and Imperial Ethiopian Government, <u>Statistical Abstract, 1967 and 1968</u>.

Sources: Trade Returns of the Customs Administration of the Imperial Ethiopian Government, quoted in Schwartz, *op. cit.*, p. 13.

Table 11. Over the same five-year periods increases in value of imports were: 1945-50, 58 per cent; 1950-55, 58 per cent; 1955-60, 30 per cent; 1960-65, 71 per cent.[1]

From 1955/56 to 1965/66 the total value of imports increased 140 per cent compared with a corresponding increase of 80 per cent for exports. Since 1945 Ethiopia's visible annual trade balance has only been positive in 1951, 1953, and 1957. These trade imbalances have been counteracted by capital inflows and, as a result, external reserves have maintained an upward trend although holdings of foreign exchange have declined.[2] Table 12 shows balance of payments details for 1965-67.

Increased exports will be needed to provide the bulk of foreign exchange. Also, increased production of import substitutes will be needed to ease the foreign exchange position. These demands will have to be met by increasing agricultural productivity in the current stage of Ethiopia's development.

Size of the Economy

The relative size of the Ethiopian economy can be assessed from the data in Table 13. In addition to a summary of national accounts, estimates of per capita GNP and the rate of growth of the economy are included.

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[1] *Ibid.*, p. 17.

[2] Zerom, *op. cit.*, p. 102.

TABLE 11 Annual value (c.i.f.) of imports by major commodity group, Ethiopia, 1961-67

Commodity group	1961	1962	1963	1964	1965	1966	1966	1967	1967
	---	---	---	thousands of Ethiopian dollars	---	---	thousands U.S.$	thousands E.$	thousands U.S.$
Food and live animals } Beverages and tobacco	14,443 }	16,912 }	14,829	14,618	20,581	31,879	12,751	23,822	9,529
Beverages and tobacco				3,793	4,910	5,096	2,038	5,005	2,002
Raw materials } Fuel and lubricants	31,285 }	29,920 }	26,617	17,075	18,113	20,639	8,256	15,746	6,298
Fuel and lubricants				23,871	23,912	27,144	10,857	31,544	12,617
Chemicals } Manufactures } Machinery and transport equipment	189,503 }	210,170 }	234,811	23,020	27,117	31,931	12,772	34,503	13,801
Manufactures				122,580	137,759	137,031	54,812	128,372	51,349
Machinery and transport equipment				99,680	140,512	146,259	58,504	116,780	46,712
Other	399	-	400	2,996	2,767	4,339	1,736	2,000[a]	800
Total	235,630	257,002	276,657	307,633	375,671	404,318	161,726	357,772	143,108

[a]Estimate based on Zerom's estimation of balance of payments data. Zerom, *op. cit.*, p. 106.

Source: Imperial Ethiopian Government, *Statistical Abstract, 1967 and 1968*, quoted in Schwartz, *op. cit.*, p. 117.

TABLE 12 Summary of balance of payments accounts, Ethiopia, 1965–67

Item	1965	1966	1967

TABLE 12 Summary of balance of payments accounts, Ethiopia, 1965-67

Item	1965	1966	1967	1967
	--millions of Ethiopian dollars--			millions U.S.$
I. Current Account				
1. Exports (f.o.b.)	289.9	277.5	252.5	101.0
2. Imports (c.i.f.)	-375.7	-404.4	-357.8	-143.1
Trade balance	- 85.8	-126.9	-105.3	- 42.1
3. Service account (net)	20.0	28.1	26.9	10.8
4. Investment income	- 9.5	- 12.7	- 17.2	- 6.9
5. Transfers (net)	32.8	29.7	15.7	6.3
Balance on current account	- 42.5	- 81.8	- 79.9	- 31.9
II. Capital Account				
1. Private capital (net)	26.6	16.0	16.4	6.6
2. Public capital (net)	45.2	56.3	26.3	10.5
Capital flow	71.8	72.3	42.7	17.1
3. Balancing items				
errors and omissions	5.0	1.6	- 6.2	2.5
Change in foreign exchange reserves	- 34.3	7.9	43.4	17.4
Total capital account	42.5	81.8	79.9	31.9

Source: Zerom, *op. cit.*, p. 106.

TABLE 13 Annual summary of national accounts, Ethiopia, 1961-67

Item	Summary of national accounts at indicated year								
	1961	1962	1963	1964	1965	1966		1967	
	----------millions of Ethiopian dollars--------					--------------millions---------------			
						E.$	U.S.$	E.$	U.S.$
1. Gross domestic product at current factor cost	2,323.3	2,406.9	2,510.5	2,801.6	3,193.3	3,388.0	1,355.2	3,488.1	1,395.2
2. Net income from abroad	-18.4	-9.8	-13.8	-15.4	-9.5	-12.7	-5.1	-16.5	-6.6
3. Gross national product at factor cost (1+2)	2,304.9	2,397.1	2,496.7	2,786.2	3,183.8	3,375.3	1,350.1	3,471.6	1,388.6
4. Indirect taxes (net of subsidies)	111.1	127.0	137.1	174.5	202.1	220.8	88.3	227.7	91.1
5. Gross national product at market prices (3+4)	2,416.0	2,524.1	2,633.8	2,960.7	3,385.9	3,596.1	1,438.4	3,699.3	1,479.7
6. Gross fixed capital formation	284.2	308.2	311.9	353.2	400.3	447.7	179.1	511.4	204.6
Land, buildings and works	208.9	227.4	226.4	253.1	273.8	304.5	121.8	361.9	144.8
Machinery and equipment	75.3	80.8	85.5	100.1	126.5	143.2	57.3	149.5	59.8
7. Increase in stocks (livestock)	10.9	8.7	8.8	9.9	10.7	10.9	4.3	10.1	4.0
8. Gross domestic capital formation (6+7)	295.1	316.9	320.7	363.1	411.0	458.6	183.4	521.5	208.6
9. Per capita GNP (at market prices)	114.2	117.2	120.2	132.8	149.2	155.4	62.2	156.3	62.5
Implicit price index (1961=100)	100.0	99.2	100.1	106.5	115.6	116.5		113.6	
Annual rate of growth in real GDP (at 1961 prices)[a]	-	4.5	3.4	4.9	5.0	5.3		5.6	

[a]Increase of current GDP(=GDP_t) over GDP of previous year (=GDP_{t-1}); in each year (t), GDP_{t-1}=100.

Source: Imperial Ethiopian Government, Statistical Abstract, 1967 and 1968, p. 125.

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Level of Contemporary Development

Agriculture

Improving the output of subsistence food crops for the bulk of the population is an important contemporary need. It has been estimated[1] that food production must increase annually at 4 1/2 per cent in order to achieve the accepted minimum daily requirement of 2,300 calories per person[2] and maintain exports at their present level. This is approximately 180 per cent more than recent annual rates of increase in total food production in Ethiopia.[3] In recent years the Ethiopian market has witnessed food shortages; large grain imports, 1958-60 and 1965-67; a general increase in grain prices: domestic demand for grains and pulses has exceeded supply.

The annual increase in the market-dependent population has been estimated at about 3.5 per cent; in 1980

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[1]Willis G. Eichberger, "Food Production and Consumption in Ethiopia" (Addis Abeba: USAID/Ethiopia, 1968), p. 34. (Mimeographed.)

[2]George R. Allen, "The World's Food Shortage: Nutritional Requirements and the Demand for Food," in <u>Food: One Tool in International Economic Development</u>, ed. by Edwin O. Haroldsen (Ames: Center for Agriculture and Economic Adjustment, Iowa State University Press, 1962), p. 42. (This figure has been accepted as a standard for African diets. In these estimates 100 calories per day were assumed unaccounted for.)

[3]Willis G. Eichberger, "Food Production and Utilization in Ethiopia E.C. 1958" (Addis Abeba: USAID/Ethiopia, May, 1968), p. 43. (Mimeographed.)

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it will be about 65 per cent greater (6.8 millions) than in 1960. Teff (Erogrostis abyssinica) forms the basic cereal;[1] by 1980, anticipating higher per capita incomes it is likely that the demand for grains will be considerably in excess of 1.0 million metric tons (0.6 million metric tons in 1966) with a substantial swing in favor of wheat due to a relatively elastic income elasticity of demand for wheat.[2]

At Ethiopia's level of development agricultural exports are vital. During the period 1948-52, there was a total net export of wheat amounting to 37,000 metric tons; during the period 1962-66, a deterioration occurred to a total net import of 20,000 metric tons. It is unlikely that this situation will be reversed in the near future. Grain production will have to increase substantially and prices decline before Ethiopia can compete successfully on the world market again.

The trade balance for pulses appears more favorable: exports have doubled during the past 20 years. However, domestic demand appears to be running ahead of supply. Pulse exports have made an important contribution

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[1]In 1966/67 the total production of teff was estimated at 1,285.5 thousand metric tons; wheat production 738.9 thousand metric tons (see Table 6).

[2]Miller, et al., Development of Agriculture . . ., Final Report; pp. 7-8.

to foreign exchange earnings in recent years but a major effort will be required to prevent deterioration also.[1]

There appears to be general agreement that immediate gains in food and fiber supply and in increased exports can be derived most effectively through encouraging land development by medium- and large-scale commercial farm enterprises.[2] Currently such land may be undeveloped, or may be farmed by traditional methods. Market orientation[3] of producers is important because the concept of producing a marketable surplus, already established in producers' minds, facilitates the processes of modernization and commercialization. It is also important, however, not to neglect the small, traditional farmer who represents the great majority of the population ". . . for unless the effects of future plans eventually reach down to this majority group, the social objectives of the long term plan will not be realized."[4] The importance of this group is also emphasized in the Third Five-Year Plan.[5]

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[1] Ibid., p. 8. [2] Ibid., pp. 9-10.

[3] "The term 'market-oriented' is used to indicate that a broader coverage is meant than the usual 'commercial' large-scale plantations. Location, size of farm, and the nature of the tenancy pattern may be most important factors in determining whether an area is market-oriented; in some areas, under suitable conditions, relatively small farms may prove surprisingly responsive to market incentives." Ibid., p. 9.

[4] Miller, et al., Development of Agriculture . . ., Phase I Report, p. 27.

[5] Imperial Ethiopian Government, Third Five-Year Plan, pp. 190-93.

Institutions and Infrastructure

In their broadest interpretations, "institutions and infrastructure" overlap. Institutions include specific organizations which offer public services and also those customs, habits, and social activities common to the way of life of a country. Infrastructure includes physical assets essential for these services and for the continuing economic development of the country.

It is anticipated that the government will encourage, or directly promote, the creation and development of essential infrastructure and institutions. Institutions will be related to the following activities, or public services: (1) technical instruction and demonstration; (2) technical education; (3) protection of human and animal health; (4) natural resource conservation; (5) cooperative activities; (6) credit facilities; (7) local government; (8) law and order.[1]

Enlarging the infrastructure will greatly facilitate the development of Ethiopia's economy. In giving priority to infrastructure projects, the value of the particular project in removing constraints on the development of an area and the possibility of multiple use for

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[1]Miller, *et al*., *Development of Agriculture . . .*, Phase I Report, p. 41. (These activities are not listed in order of importance but in the order discussed by Miller, *et al*. It is probable that the strengthening of local government and maintenance of law and order should have high priority in attempting an orderly processing of events in economic development.)

the infrastructure are important considerations. Usually transport and communications will have high priority. The development of marketing facilities, schools, health centers, supplies, services, credit facilities, research centers, police, and local government offices will occur either by private or public initiative according to an order of priorities appropriate to the area under consideration.[1]

The introduction of modern forms of transport and communication into Ethiopia has only begun in recent times. Probably most important to the development of agriculture is a modern network of roads and highways. The vast mountain massif, deeply eroded gorges, torrential seasonal rains, and resulting floods are all inimical to the development and maintenance of a modern road system. Thus, until recently, most transport was restricted to animal and human packs. Before 1935 there were only 1,040 kilometers of all-weather road in the Empire. During the Italian occupation of Ethiopia (1934-42) several important roads were built. An extensive highway program was inaugurated through funding from the International Bank for Reconstruction and Development (IBRD) and Ethiopian sources in 1950; the Imperial Ethiopian Highway Authority was established in 1951. More recently,

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[1]Miller, et al., Development of Agriculture . . ., Final Report, pp. 17-18.

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funds have also been made available from Sweden, the United States, and West Germany.[1] In spite of an increase of 67 per cent in the length of all-weather highways during the period 1956-67, it is estimated that approximately 45 per cent of Ethiopians still live more than 16 kilometers from an all-weather road.[2]

There are two (different) narrow gauge railways. The one between Addis Abeba and the port of Djibouri (781 kilometers), completed in 1917, plays an important role in foreign trade. The one in Eritrea, completed in 1932, links Asmera and Akordat with the port of Mitsiwa (305 kilometers). Three principal ports are Mitsiwa and Aseb, in Eritrea, and Djibouti in adjacent Territory of Afars and Issas.

Ethiopian Airlines (a subsidiary of Trans World Airlines) began operating both international and domestic flights in 1945. The internal flights have greatly improved the accessibility to remote parts of the Empire. Axum Airlines, a private company, also operates an important service for private charter hire and seasonal crop spray.

Many Ethiopians travel by bus services. These are operated by private companies.

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[1] Huffnagel, _op_. _cit_., pp. 91-92.

[2] Miller, _et al_., _Development of Agriculture . . ._, Phase I Report, _p. 11_.

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Post office services have increased substantially over the last decade. The Imperial Board of Telecommunications was established in 1954.

The contemporary supply of services are also inadequate for economic development. The principal supply of agricultural credit is the Development Bank of Ethiopia. A recent investigation sponsored by the IBRD and the United Nations (FAO) led to the recommendation of credit programs for selected agricultural regions with the aim of establishing a national credit agency. The first two Five-Year Development Plans indicated the importance of veterinarians, agricultural extension, plant protection, agricultural research, and marketing assistance. To date both funds and the supply of trained personnel are inadequate to institute these services. The establishment of the Institute of Agricultural Research, the Ethiopian Grain Corporation, the Livestock and Meat Board, and the Coffee Board represents a beginning toward the development of these required services.[1]

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[1]*Ibid.*, pp. 19-20.

CHAPTER III

ECONOMIC GROWTH, DEVELOPMENT, AND ETHIOPIAN DEVELOPMENT PLANS

In order to evaluate the role which different forms of mechanization play in the agricultural systems of the selected cases, a number of evaluation criteria are required. These are developed and defined in the discussion of Chapter IV. Such criteria must be consistent with both general conditions conducive to growth and development, and with specified objectives contained in the Ethiopian development plans.

The discussion of this chapter is intended to serve as background to the development of methodological procedures and evaluation criteria in the following chapter. In the first section of this chapter the distinction between growth and development is discussed. This provides a general background against which can be set the specific details of Ethiopian development planning, considered in the second section of this chapter. This discussion also serves to bring into focus those institutional changes which are part of development and are also mportant

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important considerations in deciding which among a set of alternative forms of mechanized agricultural technology is likely to be an appropriate option.

Growth and Development

A distinction is made between growth and development. The former is used to refer to increasing per capita income ($\Delta GNP/\Delta Total\ Population>1$), the latter includes growth and other concomitant changes in economic and social structure. Essentially the concept of growth is a statistic; the concept of development subsumes the gradual introduction of economic linkages, changes in economic and social institutions necessary for overall increasing economic prosperity.[1] Development subsumes general increasing prosperity. Thus, income distribution is also an important component of development but is not included in the concept of growth. The importance of income distribution is elucidated as follows:

> . . . our subject matter is growth, and not distribution. It is possible that output may be growing, and yet the mass of people may be coming poorer. We have to consider the relationship between growth and distribution of output. . . .[2]

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[1]Social welfare is a more appropriate term since it includes the intangibles of the good life. Its use is eschewed in this discussion, however, in order to avoid considerations of the components of the good life for the Ethiopian nation. This would lead into difficult anthropological considerations which are beyond the scope of this thesis.

[2]W. Arthur Lewis, The Theory of Economic Growth (London: George Allen and Unwin, Limited, 1955), p. 9.

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The Liberian case exemplifies the situation of growth without development. The annual rate of growth over the period 1954-60 averaged about 15 per cent[1] but in 1960 as a rough estimate "fewer than 5 percent of the total number of income receiving units in the economy received more than 90 percent of total domestic income in money and in kind."[2] New institutional arrangements are required to improve development. Institutional changes cannot be imported they must be created domestically.[3]

Development is a broad concept which includes growth. Policy-makers in less developed economies seek to promote both growth and development; the ramifications of the development process have an important bearing on planning any particular mechanization program. Hence, some further discussion on development will provide essential points of reference in the formulation of evaluation criteria.

In less developed economies the various sectors tend, in a dynamic sense, to be unrelated: the most typical characteristic of less developed countries.[4]

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[1]Robert W. Clower, George Dalton, Mitchell Harwitz, A. A. Walters, Growth Without Development: An Economic Survey of Liberia (Evanston, Ill.: Northwestern University Press, 1966), p. 23.

[2]Ibid., p. 65. [3]Ibid., p. 91.

[4]Albert O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1958), pp. 106-08.

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Backward and forward linkage of the economy can be observed in the way developing industries demand increasing quantities of inputs provided from either indigenous resources or imports until such time as the appropriate intermediate industries become established. Derived demand for inputs gradually extends further into the economy's productive capacity as the economy becomes more developed (and more commercialized). Backward linkage gradually harnesses available resources of the economy through economic linkages from consumer demand back to the inputs of primary production. Forward linkage involves establishing a level of demand which equates with industrial productive capacity. "Investment decisions that are taken as a result of both backward and forward linkage must be prized highly since they are sure to be particularly easy-to-take ones."[1]

Economic development appears generally to proceed as a sequence of imbalances as investments in social overhead capital stimulate the investment in directly productive activities.[2] Distortions occur as the economic linkages increasingly integrate the sectors of the economy.

The fully integrated economy is self-coordinating and self-adjusting through the price mechanism. Use of

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[1] Ibid., p. 17.   [2] Ibid., pp. 98-119.

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money becomes widespread, ways of manipulating the money economy are learned, and the market becomes an important source of information in the process of making economic decisions. Mobility of productive factors becomes a necessary condition and economic institutions, hitherto inflexible in traditional societies, become increasingly flexible and adaptive to change.[1]

As modernization proceeds, gradual integration facilitates the increasing articulation of the socio-economic system: the market processes provide neutral media in which individuals can express their own socio-economic values and attitudes, in contrast to traditional societies in which expressed values and attitudes are generally established by an elite. The articulated society is identified with the economy in which the character, education, and ethical persuasions of individual members have made important contributions. Individual achievement is an important motivation. Institutions facilitating the operation and manipulation of the market economy, i.e., the manifestations of commercialization: banking, credit, accounting, storage, transport, schools, research universities, hold a prominent place in socio-economic life. The modern economy maintains its progressiveness by a continuous process of increasing specialization which

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[1]Cyril Belshaw, Traditional Exchange and Modern Markets (Englewood Cliffs, N.J.: Prentice-Hall, 1965), pp. 108-45.

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leads to greater diversity in characteristics of its institutions and its people and an increasing complexity of social organization.[1]

Part of the process of development and modernization is a sectoral shift of resource employment from primary (agriculture, forestry, fishing) to secondary (manufacturing, mining, construction) and tertiary (service industries) production.[2] The changes taking place in the structure of production are not random, but appear to follow a universal law. As per capita income increases, secondary industry increases in size relative to primary industry, and as per capita income increases further, tertiary industry increases in size relative to both.

Ethiopian Development Plans

The First Five-Year Plan was introduced in 1957; prior to this date some individual departments such as education, agriculture, highways, and telecommunications had independently formulated plans, but there was no

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[1] Ibid., pp. 130-40.

[2] Hagen, op. cit., pp. 41-51. This phenomenon is a manifestation of Fisher's thesis which states that as incomes rise, primary sector products have increasing amounts of value added to them by processing in the secondary sector and by services in the tertiary sector. A. G. B. Fisher, The Clash of Progress and Security (London: Macmillan and Company, Ltd., 1935), subsequently verified and extended by Colin Clark, Conditions of Economic Progress (London: Macmillan and Company, Ltd., 1957).

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integrated plan of action. In the First Five-Year Plan major goals were oriented toward: (1) development of infrastructure essential for economic growth; (2) raising levels of education and technical skills; (3) accelerating agricultural development; (4) establishing processing industries; (5) directing economic policy, particularly financial policy, toward mobilizing financial and human resources for economic development.

Emphasis was given to infrastructure by the allocation of total investment $269.4 million (E$ 673.6 m.): 35.6 per cent to transport and communications; 20.5 per cent to industry; 27.0 per cent to agriculture and forestry; 8.5 per cent to education, health, and community development. During this period, annual growth of national income was estimated as being at a rate of 3.2 per cent, some 0.5 per cent below the planned rate. This was a significant improvement over 2.0-2.5 per cent for several years previous to the Plan, but since population increase during this period was at an annual rate of 1.6 per cent the annual increase in per capita income only amounted to 1.6 per cent.[1]

The Second Five-Year Plan (1963-67) had similar broad objectives to those laid down in the First Plan. However, emphasis was shifted in favor of directly productive activities to increase the output of consumer

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[1]Miller, *et al.*, *Development of Agriculture . . .*, *Phase I Report*, pp. 23-24.

goods and to create new employment opportunities for the growing population. The Second Plan stressed the following specific objectives in production: (1) extension of cultivable areas; (2) improvement in cattle raising; (3) introduction of modern large-scale industrial undertakings; (4) establishment of processing industries based on agricultural raw materials.

Investments for the Second Plan were considerably larger, estimated at $678.4 million (E$ 1.696 m.) allocated as follows: 20.9 per cent to agriculture; 18.8 per cent to manufacturing; 16.8 per cent to transport; 14.7 per cent to housing; the remaining categories of mining, power, forestry, communications and others, less than 5 per cent to each.[1]

The major goals of the Third Five-Year Plan[2] have been established as follows:

1. The fastest possible growth and development of the economy as a whole--the plan growth rate is 6% per year--and a steady if gradual improvement of the social and cultural welfare of the people of Ethiopia.

2. A steady and perceptible rise in the real standard of living for the population in terms of higher per capita incomes which would expand on average by over 3% annually. In plain terms

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[1] *Ibid.*, pp. 24-26.

[2] Imperial Ethiopian Government, *Third Five-Year Development Plan*, pp. 35-36.

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this means better dietary levels, better clothing and better housing conditions, better health standards and educational opportunities, as detailed in the sectoral chapters of the plan.

3. The building of far stronger foundations for sustained and rapid growth and development of the economy in the fourth plan period and beyond. This will particularly require the enlarging of the educational base of the population, with special attention to the provision of the skills required by the various sectors, the acquiring of a more accurate knowledge of the country's natural resources, and the improvement of the administrative capacity of the government.

4. Without sacrificing foregoing objectives, a gradual improvement in the distribution of real incomes, and increased opportunities among the different sections of the population and the various regions of the Empire.

In the agricultural sector, two main lines of policy have been adopted by Ethiopian planners: one is directed toward commercial farming which is viewed as the vehicle for rapid expansion, to provide the dynamism to the sector;[1] the other is directed toward "peasant, subsistence agriculture" to raise standards of the mass of the people.[2] The planners intend to encourage private national and foreign entrepreneurs with the expectation that rapid commercial development may have a substantial impact on the economy, generating income, facilitating the establishment of infrastructure and having a local

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[1] Ibid., p. 37.

[2] ". . . Out of four million peasant households 90 per cent cultivate less than five hectares each, two-thirds of them less than one and a half hectares." Ibid., p. 190.

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demonstration effect.[1] The rate of expansion for commercial farming is anticipated to be at least 5.7 per cent annually[2] in order to compensate for the slow annual expansion in the subsistence sector, estimated at 1.9 per cent. Policy for developing the subsistence sector includes increasing the availability of improved technology through expanding extension services, increasing credit facilities, improving access to available markets, establishment of "package programs," and land reform.[3]

In order to expand exports a number of crop expansion policies have been adopted. Total agricultural export is planned to expand 72 per cent over the planning period: coffee exports to increase 27 per cent; oilseeds 214 per cent; fruits 72 per cent; pulses 60 per cent.[4]

The total Plan involves investments to the estimated sum of $1,246 million (E$ 3,115 m.), at current prices, of which 77 per cent is to be obtained from gross domestic saving. The balance plus net payments abroad will be made up by private and public borrowing from foreign sources.[5]

General development strategy for Ethiopia appears to follow four principal lines of policy: (1) meeting

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[1] _Ibid._, pp. 191-92. [2] _Ibid._, p. 37.

[3] _Ibid._, pp. 193-94. [4] _Ibid._, pp. 69-72.

[5] _Ibid._, p. 57.

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food demands for a growing population; (2) generating domestic surplus; (3) increasing foreign exchange supplies; (4) expanding industrial (agriculture, agro-industry and manufacturing) activity. Specific attention is to be given to: (1) early generation of cash income; (2) demands on scarce resources; (3) increasing the supply of foreign exchange; (4) difficulties in land tenure and health conditions; (5) government priorities for implementing research studies.

Development of the agricultural sector is expected to include: (1) encouraging private foreign investment; (2) developing and improving institutional arrangements for agriculture; (3) increasing irrigation; (4) expanding production of crops and livestock; (5) expanding agro-industries; (6) increasing mechanization and improving agricultural technology; (7) encouraging better land use practices; (8) increasing bi-lateral and multi-lateral aid programs.[1]

Evaluation criteria discussed in the following chapter are consistent with general development conditions and objectives of Ethiopian development plans. These criteria can be classified into two groups: (1) those used to evaluate financial potentials of investment

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[1]Miller, et al., Development of Agriculture . . ., Phase I Report, p. 5.

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CHAPTER IV

METHODOLOGY

Research techniques which constitute the methodology of this thesis were discussed briefly in Chapter I. The methodology falls into four distinct phases: field work, preparation of basic production data, data generation (preparation of budget models), and data analyses. The research techniques employed in each methodological phase serve to appraise, synthesize, and analyze the data from selected cases of Ethiopian agricultural systems in which different forms of mechanized technology are employed.

Selection of Cases

In terms of agricultural systems, nature establishes certain exogenous variables; man with his knowledge, skills, social values, attitudes, and customs establishes other exogenous variables and manipulates the inputs of resources available to the system.[1] The

[1]R. F. Lord, Economic Aspects of Mechanised Farming at Nachingwea: In the Southern Province of Tanganyika (London: Her Majesty's Stationery Office, 1963), pp. 12-22.

endogenous characteristics of the production function establish the interrelationships between exogenous factors of production and endogenous products each of which has an economic value in monetary or non-monetary terms depending on the method of obtaining resources and disposing of products. Dynamic situations in which these basic determinants are observed are depicted by the case studies which afford different forms of mechanization opportunities in the agricultural economy of Ethiopia.

A review of mechanization opportunities reveals a wide variety of possible situations for different forms of mechanized technology. Each situation is somewhat unique with respect to ecology and crops, seasonal availability of manpower, and markets. Consequently, the possibility of a "best" mechanization policy is excluded. Rather, designing a mechanization policy is a pragmatic exercise to be initiated after careful analyses of relevant production and demand opportunities have been surveyed. The diversity of agricultural systems and mechanization opportunities suggests a pragmatic policy will promote the efficient combination of the three forms of mechanization simultaneously.

Within the Ethiopian economy a wide range of agricultural systems can be found. This range is the array of potential alternatives, from systems of unsophisticated hand-powered technology to sophisticated engine-powered

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technology, among which policy-makers may select for the introduction of different forms of technological improvement. Four cases have been selected from different regions of Ethiopia. These four cases of dissimilar agricultural systems were selected to demonstrate the method of treating available information to obtain data suitable for the proposed economic analysis. The cases depict the following systems: (1) hand-powered agriculture, Agnale Village (Appendix A); (2) transitional animal-powered agriculture, a family farm in Chilalo Awraja (Appendix B); (3) engine-powered commercial farming, a large private farm in the Setit-Humera region (Appendix C); (4) engine-powered plantation farming, Tendaho Plantations (Appendix D). In selecting these cases, the objective of developing the system into a commercially viable unit was maintained as a principal criterion; thus, mechanized settlement schemes which have special sociological objectives were not included. Commercial viability requires the technical skills of the operator, under skilled supervision if necessary, to be adequate to handle the proposed form of technology. It also requires additional operating and investment expenses to be met out of the proceeds from increasing the system's productivity level.

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forms, along with other associated improved inputs, and favorable economic conditions for disposal of surplus (marketable) production. The data presented in the tables of the budget models establish the system for the initiating year (t=0) of each case, prepared by approximating the system observed in the field, and a synthesis for each system over an operational period of ten successive years (t=1,...,10) prepared by using the budget technique.

The uniqueness of each region precludes the possibility of assuming that each case is representative of its own particular system for the entire economy. However, each case study has been prepared to typify a particular agricultural system in a region; dynamic deviations from the average situation have been minimized.[1]

Basic Data

Sources of basic data were field observations[2] and other studies believed applicable to the selected cases because of similar ecological and socio-economic

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[1]It has been observed that case studies do not give averages but emphasize the dynamic nature of agriculture; averages tend to neglect differences of operational efficiency of systems which case studies can embody. Henry C. and Anne Dewees Taylor, The Story of Agricultural Economics in the United States, 1840-1932 (Ames: Iowa State University Press, 1952), p. 358.

[2]Field work was conducted over the period of 19 months, October 1967-April 1969, during which members of the Mechanization Study Team traveled in Ethiopia and throughout eight selected countries of Equatorial Africa.

conditions. The objectives of personal visits to the location of each case were, firstly, to observe the local ecology, the agricultural system, and assess potential for change and development; secondly, to meet and interview local persons who know the area well. Such persons represented a variety of occupations: farmers, agriculturalists, civil servants, teachers, missionaries, medical doctors; both Ethiopians and other nationals.[1]

In order to facilitate the collection of specific information about production, processing, and disposal of agricultural outputs from the local system, a schedule was drafted which provided a guide to the course of interviews. The schedule was designed to serve as a checklist for specific questions rather than as a questionnaire; the areas of inquiry have been listed in Appendix E. A number of inquiries are included in the schedule about which an average local inhabitant is unlikely to have precise information. Such information was subsequently obtained from members of the Mechanization Study Team and other relevant sources.

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[1]Most educated persons in Ethiopia are competent in English. However, many interviews in the field were conducted in Amharic; the author is indebted to Ato Seyoum Solomon and Ato Solomon Bellete both for their company on these field trips and their frequent assistance afforded as interpreters.

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The objectives of the first two methodological phases are to obtain sufficient information to describe the structures of the agricultural systems as they actually exist. Budgeting is used in the third methodological phase to estimate the probable outcomes which can be expected for the productive processes based on a set of stated assumptions. Two analytical approaches are employed in the fourth methodological phase. Firstly, the benefit-cost analysis technique is used to assess the relative levels of financial returns to be expected from investment in the mechanization of different agricultural systems. Secondly, other criteria selected from stated objectives contained in the Five-Year Plans have been employed to assess the relative values of new levels of mechanized technology.

Budget Models

Budget Technique

The budget technique is essentially a synthesis used to combine data from various sources to generate new data for subsequent analysis. Data synthesis may be used to determine which set among several sets of assumptions appears the most economic as a basis for planning improvement for a single system, or which among several systems (each synthesized on a different set of assumptions) appea

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appears to promise the best level of expected returns as a basis for selecting a system having economic merit for further improvement. For each individual agricultural system, budget analyses

> . . . should undertake to determine in advance how profit or loss differs if each of several different systems of operation is followed. It should carry such analysis to the point that the farmer is satisfied in his own mind as to which of the alternative systems of operation will prove most useful . . . it should also indicate in advance what can be expected over the next 5-10 years.[1]

The budget technique has been known for over three hundred years.[2] The procedure calls for: (1) information and description of the agricultural system; (2) determination of the future plan for the system; (3) determination of gross returns; (4) determination of operating costs; (5) computation of net returns and other economic features of the system.[3]

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[1] John D. Black, Marion Clawson, Charles R. Sayre, and Walter W. Wilcox, Farm Management (New York: The Macmillan Company, 1947), p. 146.

[2] "Writings on budgeting or 'advanced estimating' as it was then called appeared in German literature through the years since 1663 in connection with valuation, appraisal, sale, leasing and kindred subjects." Merle Eugene Quenemoen, "A Study of Costs and Returns for Dry-Land Farms in the Triangle Area of Montana with Emphasis on Operator's Labor, Machinery and Land" (unpublished Ph.D. dissertation, Michigan State University, 1966), p. 12.

[3] Walter J. Roth, "Farm Budgeting in Germany," Journal of Farm Economics, XI (October, 1929), 624.

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The first two requirements are met in the synthesis of the system for the initiating year and the basic assumptions of the budget. Returns and costs are determined through operating budget procedures. The accuracy and consequent usefulness of budget models depends on the validity of the assumptions and the closeness of approximation to reality.

Scope and Application

The scope for making assumptions about prices in both product and factor markets is limited because comprehensive future price forecasts are unavailable for the Ethiopian economy. Thus, two sets of budget models have been computed. In the first set, constant accounting prices, based on the actual observations of the systems, are employed to generate data for the first analyses discussed at the beginning of Chapter VI. In the second set, accounting prices for major outputs and inputs, reflecting anticipated price trends to general data, are employed for a reappraisal of the analyses discussed at the end of Chapter VI.

In order to synthesize an agricultural production system, basic assumptions derived from agronomic, engineering, and socio-economic observations must be related to parameters established by the climatic features of the environment and the cropping patterns established in the region. Th

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region. These data are contained in Table 1 of each appendix, A to D.

Basic Assumptions

The set of basic assumptions specific to each budget model are contained in Table 2 of each appendix, A to D. The areas in which basic assumptions were made are: subsistence crop requirements and cash crop production, tools and equipment, crop prices and yields, operational rates for labor and machinery, and establishment costs. In addition, the conditions for obtaining loans, and certain other requirements to be provided government funds must be established.

1) Subsistence Crop Requirements and Cash Crop Production

A particularly difficult problem encountered in economic analyses of subsistence agricultural systems lies in the fact that few outputs or inputs are involved in cash transactions of a local market. Assigned cash values are arbitrary but in accord with the small proportion of transactions taking place in local markets which provide some guide for accounting prices. In the process of budgeting, outputs and inputs are valued in cash, yet to consider final annual net output as a single cash figure distorts the analysis of the system. Therefore, in Agnale, Chilalo, and Setit-Humera cases, which contain significant amounts of "non-cash" production, "non-cash" returns, and "non-cash" input costs, valuations are established in accord with local prices and the accounts of productive processes in the budget models are organized in separate non-cash and cash categories.

Agnale and Chilalo are subsistence agricultural systems; in computing production possibilities first priority is given to meeting domestic food requirements. These requirements are based on the number of people to be fed per producing unit and established levels of food intake. As the productive capacity of the system increases, due to improved crop yields and improved operational efficiency, increasing capacity to produce cash crops is assumed.

2) Tools and Equipment

In the initiating year (t=0), there is an inventory of tools and equipment for the case as it was observed as an operational system. Improved tools and equipment are introduced during this year in order that the level of mechanized technology considered appropriate for each system is in operation at the beginning of the operational years (t=1,...,10). In this way a difficult problem of incomparability between inventories is avoided. This problem arises due to the fact that the improved levels of technology of Agnale and Chilalo require the introduction of new tools and equipment in the first operational year of the budget (t=1), in contrast to

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Setit-Humera and Tendaho in which the actual form of technology is already established. If it were assumed that new capital equipment be introduced in the first operational year of the budget model (t=1), then another inventory would have been necessary for the initiating year (t=0). In the first two cases, old tools and equipment gradually would depreciate and disappear from the system as improved equipment were put into use, beginning in the first operation year (t=1). In the second two cases, however, improved equipment would be already in operation in the initiating year: replacement equipment would not be necessary until the end of respective depreciation periods for each category of equipment, i.e., toward the end of the budget period (t=5,...,10). Shifting large capital injections away from the initiating year which would occur only in the second two cases would cause significant changes in the benefit-cost analyses results due to the discounting procedures. Thus, to make the case studies comparable, depreciation is charged in the initiating year on the inventory of equipment actually observed to be in use, whether old or improved equipment, and the new inventory is introduced in the initiating year to form the basis of the production system for the operational years (t=1,...,10) and the basis of depreciation charges during these years.

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Depreciation is charged on the basis of fixed annual percentage of the original acquisition cost. This procedure is consistent with the situation pertaining throughout Equatorial Africa of no salvage market existing for used equipment.[1]

3) Prices and Yields

Prices and yields are major determinants of gross value of the total product; a percentage waste estimate is also incorporated into this computation. The first set of computations for the budget models incorporates constant prices for all outputs and inputs. These data were obtained from field observations and related studies. Trends in product market prices, sensitivity to changing input prices, and modified accounting prices (crude shadow pricing) to reflect changing economic circumstances are employed subsequently. Thus, in the first instance prices for outputs, inputs, and capital reflect the 1968 markets, the year in which field observations were conducted.

Yield data are drawn from field trials and other related agronomic studies. Two production levels have

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[1]This fact is most important in explaining the difficulty experienced in attempting to introduce new forms of agricultural technology into areas where agricultural productivity is generally low and the salvage value for any equipment is low. New equipment will have an economic cost greater than zero, probably even greater than expected new levels of output, and there is no economic compensation for abandoning the use of old equipment which is still productive although at a low level of efficiency.

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been computed for each budget model based on high- and low-level yields. The high-level yield assumptions reflect commercial yield attainable under conditions of superior management although somewhat less than maximum yields realized by experiment stations; low-level yield assumptions reflect average to poor management conditions. Both high- and low-level yield assumptions represent improvements over current production levels.

4) Operational Rates: Labor and Machine

Rates for labor and machine operations in the field are based on information for the current technology observed during the course of field observations. These rates are employed in the initiating years. Assumptions made of improving efficiency and shifts from hand- to animal- or to engine-powered operations are based on experimental work and observations made either in the actual area or in areas where conditions are sufficiently similar to warrant the transference of relevant data.

5) Establishment Costs

Only in the Agnale case are establishment costs necessary for the development of the budget model. In the other three cases improvements in the level of mechanization are facilitated by production of annual crops which yields returns in the year of planting. Tree crops in Agnale do not begin to bear fruit until four years after planting (i.e., planting, t=1; begin fruiting, t=4).

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6) Credit and Loans

Three types of loans are assumed: crop loans to cover short-term operations less than the duration of the annual season; medium-term loans to cover the purchase of equipment, implements, and tools; long-term loans to cover heavy capital establishment costs. Assumed annual rates of interest 8 per cent computed on a monthly basis for crop loans; and 7 per cent for the medium- and long-term loans. The medium-term loans are assumed to be repayable in equal installments over seven years, except for equipment depreciating in less than this period in which case repayment is computed over the depreciation period. Any negative cash margin at the close of any year's operation is accommodated on overdraft terms (short-term loan of one year) at 7 per cent per annum interest.

7) Additional Requirements

Certain additional requirements are assumed in Agnale, Chilalo, and Setit-Humera. These are outside the assumptions necessary for the budget models but should be mentioned at this juncture since they are included in each case study. Additional requirements, introduced during the first operational year of the budget, consist of capital and operating expenses necessary to introduce the proposed changes in mechanization, i.e., expenditures incurred by the government in order to operate the program. These expenses are in addition to farm operation costs but are part of

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are part of the exogenous components of the system and, therefore, are included in the benefit-cost analysis, being part of the total cost structure of the project.

No additional requirements are included for Tendaho. In large-scale plantation farming the management is assumed to be technically competent to control and finance the introduction of its own technical requirements.

The Models

Budget model data are tabulated in a comparable form for each case study. The first two tables of each appendix, A to D, contain the ecological data, established cropping operations of the initiating year, and basic assumptions. Data are generated from these initiating situations and assumptions. The complete budget model includes the following generated data for each case study: annual income accounts (Table 3); annual input accounts (Table 4); annual crop areas and summary of annual total production (Table 5); summary of annual incomes (Table 6); operational use of labor (Table 7); other inputs (Table 8); summary of annual total costs for inputs--excluding financial costs (Table 9); annual financial costs (Table 10); summary of annual budget model accounts (Table 11).

Budget model computations were based on estimations of high- and low-level yields to establish maxima and minima production possibilities. Additionally, in the cases c

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the cases of Chilalo, Setit-Humera, and Tendaho, two strategies were assumed to exemplify two alternative approaches to improving mechanization in the systems. In Chilalo the strategies are designed to introduce either improved oxen and equipment (strategy I: oxen power) or the facilities of a tractor hire service (strategy II: tractor power). In Setit-Humera the strategies are designed either to mechanize only the primary tillage operations by tractor power (strategy I: labor intensive) or to use tractor power and combines extensively (strategy II: machine intensive). In Tendaho the two strategies are designed either to produce raw cotton (strategy I: raw cotton) or ginned cotton lint and cotton seed (strategy II: ginned cotton).

In the systems depicted by Chilalo and Setit-Humera a substantial degree of integration into the market system has already taken place: surplus cash crops are produced. Thus, a simple decision-making algorithm which shifts sequential annual areas of cash crops according to the level of gross operating profit on cash crops grown in the previous year has been built into the budget models of these two cases. These are recursive algorithms[1] based on the established practice of local farmers to determine the area of crops sown in each succeeding year.

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[1]See Appendix B, pp. 286-90 and Appendix C, pp. 321-23.

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According to ruling market prices, gross operating margin per unit area is determined on the basis of gross value product less total costs of direct inputs. Allowing for domestic crop requirements, the areas of more profitable crops are increased and the areas of less profitable crops are decreased in each succeeding year.

Benefit-cost Analysis

Benefit-cost Technique

The process of introducing improved mechanized technology into already established agricultural systems involves the local community, or the government, or both, in investments in implements, machinery, equipment, and modern inputs. Benefits derived from such investment may be classified into three groups: (1) primary benefits which are the financial rewards to resulting higher levels of agricultural productivity; (2) secondary benefits which are those objectives of economic development concomitant to achieved higher levels of productivity (e.g., generation of income, cash, and non-cash; employment and distribution of income; export and import substitution potentials); and (3) intangible benefits which are important in the overall development process but are realized without being specifically engineered in any particular single project (institutional changes which emerge gradually in the process of development; training individuals

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individuals in new technological skills; growing familiarity of individuals with the developing institutions of the market and the price mechanism).[1]

Primary benefits are relatively easy to evaluate because of their financial nature. However, in many cases the outputs and inputs of the systems under analysis are assigned accounting prices although the actual goods and services do not pass through a market. Thus, the financial nature of the primary benefits frequently reflects an accounting convenience rather than an account of market transactions.

In developed market economies the efficient functioning of the market system depends on a set of conventional assumptions: (1) consumers are rational (maximize total utility), they experience diminishing marginal utility, and utility functions between individuals are independent; (2) producers are rational

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[1]These are the "side-effects" of large infrastructural projects which Hirschman emphasizes are of great importance in the development process: ". . . projects have a variety of more subtle, yet perhaps highly important and powerful effects, from the acquisition of new skills to the greater readiness, on the part of the consumers of the project's outputs, to produce for the market; from the stimulation of entrepreneurship to the learning of cooperation and discipline, from backward and forward linkages to greater propensity to engage in family planning; from increased literacy to greater confidence in the ability of one's own country to achieve progress--not to forget the negative effects such as new or heightened social and ethnic tensions, fresh opportunities for spreading corruption, etc." Albert O. Hirschman, Development Projects Observed (Washington, D.C.: The Brookings Institution, 1967), p. 161.

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(maximize profit), they experience decreasing returns, production functions between individual producing units are independent; (3) goods and services are marketable; and (4) assumptions which affect the degree of perfection in the market, (a) degree of optimality in distribution of income, (b) degree of factor mobility, (c) availability of market information, (d) level of employment of productive factors.[1] In considering alternative proposals to invest in mechanization programs in Ethiopia the commercial market's level of development is clearly an inadequate guide for optimal allocation of new investment funds becoming available for development projects. In the first place, in common with large government-sponsored investment proposals in any economy, the size of the investment is likely to distort market prices in the region of investment; secondly, alternative proposals usually

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[1]In equilibrium the operation of the capital market of the market economy is able to produce a future flow of goods just sufficient to compensate for consumers' sacrifices of present consumption. "Profit maximizing producers will make their investment plans in such a way that the present value of their future profits is at a maximum. This requires that they invest up to that point at which the present value of the net revenue stream made possible by the marginal dollar of investment is just equal to the dollar of cost, where net revenue of a period is defined as the difference between gross revenue and current costs. This principle can also be expressed on an annual basis: the firm invests up to that point at which the annual rate of return on the marginal dollar of investment (the marginal efficiency of investment) is just equal to the interest rate." Otto Eckstein, _Water-Resource Development: The Economics of Project Evaluation_ (Cambridge, Mass.: Harvard University Press, 1965), pp. 43-44.

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entail a choice between different regions and therefore involve social criteria for which the market tends to be ineffectual; thirdly, the commercial market mechanism in Ethiopia is of little consequence beyond the few metropolitan areas of the Empire. Another decision-making device is therefore necessary to indicate the relative returns to alternative investment proposals. Benefit-cost analysis offers an appropriate alternative.

Benefit-cost analysis is a technique which takes into account streams of benefits, generated over time, and the concomitant incurred costs, from the initiating year of the proposed investment. Thus, by discounting all benefits and costs to the "present" (t=0) each alternative investment proposal may be viewed as a single sum of net benefits. The proposals may each have the same or differing planning horizons but all can be put on a comparative basis viewed from the commencement of the project. The discounted flow of benefits less discounted operating costs is the "present value" of the project and when the total discounted quantity of capital required to generate this present value is also deducted the "net present value" is derived. Viewed from a single point in time, interest charges and depreciation cost are excluded from the computations since these are costs incurred by using capital through time.

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The benefit-cost analysis procedure affords decision-making rules which are used either to accept or reject a proposal. Proposals may be ranked according to one or a combination of selected criteria. Values for these criteria were determined in the case studies with the aid of the computer program which has already been developed and tested.[1]

Scope and Application

Benefit-cost analyses may be formulated to reduce decision-making to a single exercise of rejecting or accepting alternative proposals according to predetermined values for a selected criterion. In this thesis the forms of mechanization represented in four case studies are not considered as alternatives to be either accepted or rejected. Rather, the problem is to determine relative anticipated levels of returns to proposed investments and concomitant anticipated secondary benefits. Intangible benefits are not included in the quantitative analyses; they are nonetheless important, however, and should receive proper qualitative consideration before final decisions are made.[2] Benefit-cost analyses were carried out on

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[1]Robert F. Ranger, Benefit Cost Methods for Project Appraisal: A Computer Program, Agricultural Economics Report No. 149 (East Lansing: Department of Agricultural Economics, Michigan State University, November, 1969).

[2]One way to treat intangibles is to ignore them. However, their importance in the overall development

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primary benefits represented by the financial data generated in the budget models and concomitant secondary benefits were analyzed separately. By treating primary and secondary benefits separately in analyses and intangibles qualitatively, tenuous discussions involved in deciding which secondary (and intangible) benefits should be included, and their valuation, are avoided although the problem of selecting satisfactory accounting prices remains.[1]

The benefit-cost criteria, discussed below, are employed as measures of financial performance. In isolation from other analyses, the benefit-cost analysis technique cannot be considered complete since other important criteria, essential parts of the overall approach to development planning, remain outside its scope. Each criterion is defined to measure a single aspect of

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process should not be neglected and even if, by definition, intangibles are not commensurable with other benefits and costs, clues to their impact on development can often be given in the process of systems analyses. Roland N. McKean, Efficiency in Government Through Systems Analysis: With Emphasis on Water Resource Development (New York: John Wiley and Sons, Inc., April, 1958), pp. 60-63.

[1]"The real art of cost-benefit analysis is to assign prices to goods and services which do reflect their real costs to society (when they are inputs, i.e. used up) and their real benefits (when they are outputs, i.e. produced)." Ian M. D. Little and James A. Mirrlees, Manual of Industrial Project Analysis in Developing Countries, Vol. II: Social Cost Benefit Analysis (Paris: Development Centre of the Organisation for Economic Co-operation and Development, 1969), p. 86.

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financial performance, thus, taken alone, no single benefit-cost criterion can be considered an adequate measure of financial performance.

The Planning Horizon

In each case a time period of 10 years is employed as the planning horizon. However, since mechanization programs are envisaged as a continuing phenomenon of economic change, reinvestment in equipment to replace that fully depreciated was maintained throughout the period in all the cases.

Fixing a single time period for the planning horizon raises a problem of comparability between the cases. Capital investment in tree crops incurs relatively heavy initial investments which have greater longevity than investments in perennial crops, implements, and equipment. In Chilalo, Setit-Humera, and Tendaho perennial crops are the basis of cash incomes but in Agnale, the main cash crops are citrus fruits. A maximum limit in estimating output and input prices is around 10 years but yield computations show tree-crop output to be increasing annually for at least 16-18 years (t=20-22) after the orchards begin fruiting. In the other cases, some negative net present values were decreasing; suggesting that over a longer period positive net returns may be anticipated. Approximations of the budget models for 20 years, therefore, were computed for all cases. In cases of

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Chilalo, Setit-Humera, and Tendaho, these computations consisted of reiterations of year 10 (t=10) 10 times; in the case of Agnale, increasing annual citrus yields were incorporated to approximate budgets for years t=11-20. In the 20 year approximations some negative net present values become positive.

The Discount Rate

Clearly, evaluation of investment alternatives by the benefit-cost analysis technique is significantly influenced by the selected discount rate. Two extreme cases are posited: (1) investment opportunities with no capital rationing, and (2) investment opportunities with capital rationing.[1] The first case assumes that investment capital can be readily borrowed in the capital market and can be liquidated completely in the event that the investment project ceases to be profitable. In this case, investment should proceed in any given project as long as the internal rate of return (i_o) from marginal investment is higher than the market rate of interest (i_m), i.e., $i_o \geq i_m$. The second case assumes that the investor seeks to maximize the present value of net returns to a fixed investment

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[1]The intermediate case, partial capital rationing, embraces a continuum of situations in which investment units (i.e., firms or governments) can borrow in the capital market and can liquidate some, but not all, investments in the event of the capital assets proving unprofitable. McKean, op. cit., pp. 76-87.

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budget when faced with a set of investment proposals from which the invested capital, once committed, cannot be liquidated for future re-investment. In this case the market rate of interest becomes irrelevant: the present value of net returns is maximized when the sum of discounted streams of net benefits just equals the budget constraint using the internal rate of return of the marginal project. Thus, the marginal internal rate of return (MIRR) becomes the appropriate discount rate in the case of capital rationing. If investment continues until there are no additional projects which yield more than the market rate of interest, then MIRR equals i_m.

The first case is an extreme situation which has little bearing on investment in productive assets. The situation for individual firms operating in a well-developed market economy appears to be that of the intermediate case (partial capital rationing) in which some investment is capable of liquidation. The extent to which the intermediate stage approaches either end of the continuum represented by the two posited cases depends on the extent to which the initial investment can be liquidated.[1]

In the case of loans to governments for development projects in less developed economies, the market system is seldom well-developed. Moreover, budget

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[1] Ibid., p. 85.

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constraints are fixed by votes in the donors' and recipients' respective governments and, once committed, even partial liquidation of investments is unlikely. Thus, the situation depicted by the case of capital rationing appears to give the appropriate context in which to select the discount rate.[1]

The discount rate employed for a given set of investment proposals will depend on the size of the budget constraint, since the budget determines the number of proposals which can be considered. The selected MIRR will be higher, the smaller the given budget constraint. In considering the entire range of investment opportunities in an economy the expected MIRR will be at least the estimated opportunity cost of capital.

A discount rate of at least 5-6 per cent must be chosen because governments can earn this rate of return by investing funds abroad. Most less developed economies can expect to achieve a social return to investment of 10 per cent and it may not be unreasonable to anticipate 15 per cent.[2] These are high interest rates but the contention is that developing countries are concerned to expand surplus social value as rapidly as possible; one way to achieve this objective is to invest only in projects affording high rates of return.[3]

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[1] Ibid.

[2] Little and Mirrlees, op. cit., p. 96.

[3] Ibid.

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The Development Bank of Ethiopia charges 7 per cent interest on agricultural and fishery loans and 8 per cent on other loans.[1] Thus earnings on direct investments should be anticipated as greater than these interest charges. One estimate of the opportunity cost of capital in Ethiopia has been estimated at 10 per cent per annum;[2] this figure has been used for the discount rate in the benefit-cost analyses, since it is above the current interest charges for development loans and approaches estimates of social returns to investment.

Evaluation Criteria of Financial Performance

This first group of evaluation criteria consists of seven benefit-cost criteria used to evaluate the financial potential of proposals to invest in different forms of mechanization: net present value (NPV); payback period (PB), i.e., break-even over time; internal rate of return (IRR); benefit-cost ratio (B/C); and three modified benefit-cost ratios, NPV in relation to capital costs

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[1]Harry J. Robinson and Ato Mammo Bahto, An Agricultural Credit Program for Ethiopia, Report No. 9, SRI Project IU-6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, January, 1969), p. 187.

[2]U.S., Agency for International Development, "Application to the U.S. Agency for International Development: Shashemene Agricultural Development Project" (Addis Abeba: USAID/Ethiopia, 1970), p. 32. (Mimeographed.)

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(NPV/K), NPV in relation to salary costs for technical personnel (NPV/T_W), NPV in relation to salary and supporting costs for technical personnel (NPV/T_{WS}). These criteria are defined at this juncture; computed evaluations are tabulated in Chapter VI.

Net Present Value

NPV, which is in dollars, is defined as follows:

$$NPV = \sum_{t=0}^{T} \frac{TR_t}{(1+i)^t} - \left[\sum_{t=0}^{T} \frac{O_t}{(1+i)^t} + \sum_{t=0}^{T} \frac{K_t}{(1+i)^t} \right],$$

where total revenue for each year (TR_t) is the total annual benefit expected from the project, total costs for each year consist of operating costs (O_t) and capital costs (K_t), all discounted to the initiating year at a selected interest rate (i).

NPV decreases with increasing discount rates as illustrated in Figure 3. A decision-making rule can be formulated on the basis of the NPV: the investment project is acceptable if $NPV \geq 0$ when discounted at an appropriate rate. Thus, at the discount rate employed, an $NPV \geq 0$ indicates an investment opportunity, when viewed from the initiating year (t=0), which yields higher income streams than can be obtained by investing in stocks or bonds at the same market interest rate.

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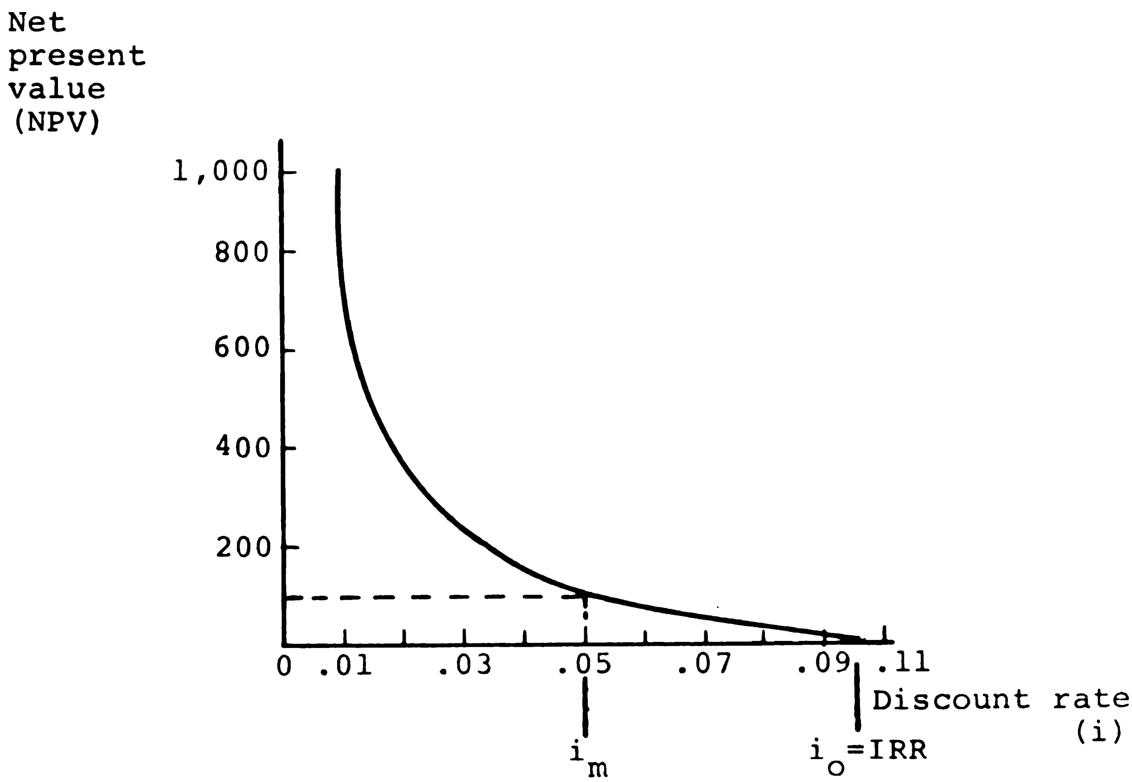

FIGURE 3 Relationship between net present value and discount rate

Source: William J. Baumol, Economic Theory and Operations Analysis (2nd ed.; Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965), p. 441.

Payback Period

PB is the number of years of operation required before the net discounted benefits are equal to the discounted cost of capital investments. The year in which net present value changes from negative to positive is the payback period.[1]

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[1]Demonstrated in the following definition of NPV:

$$NPV = \sum_{t=0}^{T} \frac{(B_t - O_t)}{(1+i)^t} - \sum_{t=0}^{T} \frac{K_t}{(1+i)^t}$$

, where B = benefits (outputs)
O = operating costs (inputs)
K = capital costs
t = year of operation
T = planning horizon

Let NPV ≤ 0 for $t = 0,\ldots,p-1$
and NPV > 0 for $t = p,\ldots,T$
Then p is the payback period.

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A decision-making rule can be formulated from the payback period (break-even criterion): Choose the project with the shortest payback period. This criterion ignores benefits that may accrue after the payback period. Nevertheless, it is a useful guide when risk is high, or a considerable degree of uncertainty exists and there is concern to recover investment quickly.

Internal Rate of Return

IRR is defined as that discount rate which reduces NPV to zero. The decision rule is to accept the project if IRR is greater than the market rate of interest. Thus, if the IRR (i_o) is greater than the market rate of interest (i_m), then the project can exactly repay the capital investment costs and pay a return to investors above the market rate (i.e., $i_o - i_m > 0$).[1]

Benefit-cost Ratio

The B/C, which is a monetary ratio, is defined as follows:

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[1]If the economy were in competitive equilibrium then one value for IRR would result in an NPV of zero for all investment opportunities. The value for IRR would be the marginal efficiency of capital defined as follows: ". . . that rate of discount which would make the present value of the series of annuities given by the returns expected from the capital-asset during its life to its supply price." John Maynard Keynes, The General Theory of Employment Interest and Money (London: Macmillan and Company, Ltd., 1960), p. 135.

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$$B/C = \sum_{t=0}^{T} \frac{TR_t}{(1+i)^t} \left[\sum_{t=0}^{T} \frac{O_t}{(1+i)^t} + \sum_{t=0}^{T} \frac{K_t}{(1+i)^t} \right]^{-1} .$$

The decision-making rule is to accept the project if $B/C \geq 1$ for all $i < i_o$(IRR). Thus, when viewed from the initiating year (t=0), benefit streams are worth more than associated costs in acceptable projects until that interest rate is charged which brings NPV to zero.

Modified Benefit-cost Ratios

The conventional benefit-cost ratio, just defined, assumes that the sum of inputs represents the total of scarce resources. In development planning it is often most economic to maximize the use of one scarce resource. Generally, the scarce resource is considered to be capital but in less developed economies this frequently is not the case since aid funds are often more readily available than the supply of technically skilled personnel or some other specifically scarce input.

Modified benefit-cost ratios employed in these analyses express NPV as a fraction of an arbitrarily selected resource designated as the scarce resource for decision-making in the context of economic development in Ethiopia. Each fraction expresses anticipated net average returns to all employed resources per unit of the one selected resource. The following three modified benefit-cost ratios have been employed:

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1. NPV in relation to capital costs

$$\frac{NPV}{K} = \frac{\sum_{t=0}^{T} \frac{TR_t}{(1+i)^t} - \left[\sum_{t=0}^{T} \frac{O_t}{(1+i)^t} + \sum_{t=0}^{T} \frac{K_t}{(1+i)^t}\right]}{\sum_{t=0}^{T} \frac{K_t}{(1+i)^t}} .[1]$$

2. NPV in relation to salary costs for technical personnel

$\frac{NPV}{T_W}$: the numerator of the fraction is the NPV as defined above; the denominator consists of the sum of discounted salary expenses paid to professional technical personnel.

3. NPV in relation to salary and supporting costs for technical personnel

$\frac{NPV}{T_{WS}}$: in this criterion the denominator includes both salary expenses paid to

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[1] $\frac{NPV}{K}$ is a similar concept to the profitability ratio in that both are measures of the returns to invested capital. The two concepts, however, are defined differently. The profitability ratio is defined as follows:

$$PR = \frac{\sum_{t=0}^{T} \frac{TR_t}{(1+i)^t} - \sum_{t=0}^{T} \frac{O_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{K_t}{(1+i)^t}} .$$

Little and Mirrlees, *op. cit.*, p. 20.

professional technical personnel and costs for supporting facilities to maintain these personnel in the field.

Trend Analysis Employing Evaluation Criteria Selected from Ethiopian Development Plans

The second group of evaluation criteria consists of four criteria developed from four objectives specified in the Ethiopian Five-Year Plans: generation of income, cash and non-cash; employment and distribution of income; productivity of productive factors; and potential for export and import substitution. These criteria are defined at this juncture.

Substantial financial returns from investment opportunities are clearly accorded high priority in the Five-Year Plans. Other non-financial criteria have also been cited for high priority in the Empire's development. Certain of these criteria have been employed as analytical concepts. These criteria relate closely to the secondary benefits of development projects discussed in the scope and application of benefit-cost analyses. The budget models were designed in such a way that these criteria may be measured.

The analytical technique employed for these criteria is the determination of trends over the budget period. Tabulated indices at selected points in time indicate changes relevant to these criteria which are occurring in the budget models.

Generation of Income

In the budget models, both gross and net income data have been generated. Net income is a useful measure of economic surplus by which, according to conventional micro-economic theory, the farm operator receives rewards for his management function, returns to invested capital, and any fortuitous economic gains accuring to the system.[1] Gross income, however, is a preferable measure of the income generating capacity of the system because gross income is the total value of the system's product to be shared among all the productive factors of the system.

Not only is income generation important but also, in relation to development policy objectives, income generation should increasingly be in the form of cash. The relative shift from non-cash to cash income generation is indicated by percentage cash data.

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[1]Management and returns to investment are legitimate charges to be included in total costs. Thus, in the strict sense, economic surplus or "rent" only accrues to "scarce" or unique qualities of management capacity which are not price-determined. Milton Friedman, Price Theory: A Provisional Text (Chicago: Aldine Publishing Company, 1962), pp. 115-18.

Employment and Distribution of Income

In the Third Five-Year Plan recognition is given to the necessity of variable targets of expansion among different sectors of the economic activity. "The foundation for the Ethiopian economy is and must long remain agriculture."[1] With only 8.1 per cent of the Empire's population resident in urban areas and approximately one-quarter of 1 per cent of the population employed as wage earners in manufacturing industries, the opportunities for wage-earning employment outside the agricultural sector are extremely limited.

Policies for economic development in Ethiopia have clearly shifted emphasis during the course of three Five-Year Plans to the current position of attempting to plan in accordance with the factor endowment and product prices of the economy. The shift has brought the agricultural sector into the position of first priority. The generation of new employment opportunities is an obvious objective to be incorporated into planning development in the agricultural sector.

This shift of emphasis in Ethiopian planning from urban to rural industry represents a movement away from the classical model which takes the position that the "capitalist" sector of the economy is capable of continuous

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[1] Imperial Ethiopian Government, Third Five-Year Plan . . ., p. 36.

expansion, employing the unlimited supplies of labor which emerge from the "subsistence" sector at a wage slightly above subsistence earnings.[1] The interpretation of this model appears to have led to an overemphasis on developing urban industry leading to increasing rural-urban income differentials; excessive stimulation of migration from rural-urban income differentials; excessive stimulation of migration from rural to urban areas; and converting "disguised underemployment to open unemployment."[2] Analysis indicates the agricultural sector rather than urban areas as the key to expanding employment opportunities in economies preponderantly endowed with agricultural resources.[3]

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[1]W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labour," The Manchester School, XXII (May, 1954), 139-91.

[2]Carl Eicher, Thomas Zalla, James Kocher, and Fred Winch, Employment Generation in African Agriculture, Research Report No. 9 (East Lansing: Institute of International Agriculture, Michigan State University, 1970), p. 9.

[3]Ibid., pp. 3-17. (However, this argument should be regarded as more relevant to short- than to long-run analyses in order to avoid excessive rural to urban migration and resulting chronic urban unemployment. Ethiopia, like other developing economies, continuously experiences acute shortages of foreign exchange, a situation which can be alleviated by both earning foreign exchange and substituting domestic manufactures for imported ones. Thus, some urban manufacturing development is also desirable. To argue that Ethiopia is entirely agricultural and must give attention only to developing her natural agricultural resources overlooks the fact that England of the 1800s, Germany of the 1850s and the United States of the 1900s were primarily agricultural economies.) See W. Arthur Lewis, "Employment Policy in an Underdeveloped

In order to evaluate the employment potential of each system, indices (t_o=100) were computed for the number of work units required and an estimate of the number of workers was made on the basis of the average work day for the region. Labor earnings over the operational period were estimated by the use of indices and the relative cash content of wage earnings was computed.

Productivity of Factors

In the process of reappraising the analyses and deciding on changes in accounting prices to reflect anticipated trends, indications of changes in factor productivity are necessary. Crude estimates of changing productivity were computed in the form of gross product per unit of input (labor, land, capital).

Potentials for Export and Import Substitution

> . . . The primary rationale for placing foreign exchange impact in a pivotal position is that the immediate bottleneck handicapping industrial[1] development in the typical underdeveloped country is found in foreign exchange stringency, and that, therefore, the effect of any new industrial enterprise upon total foreign-exchange supplies logically represents a core of consideration. The contention is that an enterprise has special merit if it helps ease the

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Area," Social and Economic Studies (September, 1958), reprinted in Gerald M. Meier, ed., Leading Issues in Development Economics (New York: Oxford University Press, 1964), pp. 378-79.

[1]This term would also include the agricultural industry as distinct from subsistence agriculture.

> foreign-exchange situation, since added development then becomes easier, not harder; on the other hand, an enterprise looses in merit if its presence serves to impair the foreign exchange situation further and automatically precludes additional development.[1]

The foreign exchange impact of any development program is determined by its capacity to either earn or to save foreign exchange. In the analyses, two aspects of foreign exchange impact are considered: first, the cost, in terms of foreign exchange, of the capital investments of the program and imported inputs; second, the degree to which the program can anticipate either earning foreign exchange (i.e., producing exports) or saving foreign exchange (i.e., producing import substitutes).

Summary

The methodology employed in this thesis consists of four methodological phases: (1) field observations, and (2) preparation of basic production data; (3) data generation (using budget techniques), and (4) data analyses (using benefit-cost analysis techniques and other criteria selected from certain specified objectives of Ethiopian development plans).

Four case studies, prepared from field observations and other relevant data, are presented in budget

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[1] Walter Krause, Economic Development: The Underdeveloped World and the American Interest (Belmont, Calif.: Wadsworth Publishing Company, Inc., 1961), p. 134.

models (Appendices A to D), non-maximized simulations of relevant data, dynamic agricultural systems. Each case is unique, depicting a particular form of mechanized technology: hand-, animal-, or engine-powered agriculture.

Basic assumptions were made with respect to subsistence crop requirements and cash crop production, tools and equipment, crop prices and yields, operational rates (and costs) for labor and machinery, establishment costs, loan and credit conditions, and additional requirements to be supplied by government financial and personnel support. Having established the basic data and assumptions for each selected case (the situation in the initiating year: t=0), budget models were employed to generate data for 10 operational years (t=1,...,10). These data, constituting the budget models, consist of: annual income accounts; annual input accounts; annual crop areas and production; summary of annual incomes; use of labor; other inputs; summary of annual total costs; financial costs; and summary of annual budget model accounts.

Generated data in each case study are presented for high- and low-levels of production. Only one strategy is developed for Agnale, but in the other cases two possible strategies are developed as alternative ways of improving or changing the form of mechanization in the system.

The benefit-cost analysis technique provides a means of evaluating a set of investment proposals for situations in which either the market mechanism is inadequate to guide the flow of investment funds (the Ethiopian case), or the nature of investment will change the ceteris paribus assumptions of the market (the general case). Benefits (primary) and costs (operating and capital) are discounted to the present (t=0) to evaluate a given investment proposal; the technique affords a set of decision-making rules either to accept or reject a proposal, or to rank a set of proposals according to computed financial returns. The criteria forming the bases for these decision-making rules are: net present value, payback period, internal rate of return, benefit-cost ratio, and appropriately modified benefit-cost ratios.

In these analyses, the benefit-cost technique is used on the financial data generated in the budget models. In this way, only primary financial returns are evaluated; the difficulties of deciding which secondary benefits (some non-monetary) might also be quantifiable for inclusion in the benefit-cost analyses are avoided. Certain objectives drawn from the Five-Year Plans are included as criteria to evaluate important non-financial benefits. These are: generation of income; employment and distribution of income; productivity of factors; potentials for export and import substitution.

CHAPTER V

SELECTED CASES OF FOUR ETHIOPIAN AGRICULTURAL SYSTEMS

The four cases depict different systems of Ethiopian agriculture into which mechanized technology may be introduced. In this chapter distinguishing features of each selected case are given brief consideration: the system, the basis for mechanization and technological improvement, and the basic assumptions for budgeting. This chapter is a summary of the budget model data described and tabulated in Appendices A to D.

Agnale Village--Hand-powered Agriculture[1]

Agnale Village, approximately 1,083 kilometers from Addis Abeba, is located in the southwestern extremities of the Empire on the rich alluvial soils of the north bank of the Baro River; the area lies at an elevation of 450 meters with a natural vegetation of wooded savannah and a hot and fairly moist climate. The village consists of a large enclosed compound containing small houses

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[1]Appendix A.

(about 15) to accommodate 190 people (20 families); the surrounding land is cultivated.

This case was selected as an unsophisticated agricultural system in which the available supply of labor is fully occupied, at certain periods of the year, in producing subsistence crops. Only hand tools are employed.

The System

The climate affords two annual cropping seasons. The dry season extends from October to March: maize, sorghum, and beans are planted in November for harvest during February-April. The wet season extends from April to September: maize and beans are planted in April for harvest August-September.

The system is balanced in such a way that there is an adequate food supply produced by a total labor force of about 48 men and boys (over 12 years old). Maximum labor demands occur during January-March, weeding and cultivating three principal crops. Each worker cultivates a single "field" of 1.3-1.5 hectares: 72 hectares being cultivated in the dry season and 38.4 hectares (a little over half of the same area) in the wet. Two unsophisticated hand tools are used: a short shafted hoe and a wooden hook.

Basis for Technological Improvement and Mechanization

The area is ideally suited for producing citrus fruits which may become the basis of cash cropping. Sesame is produced already and can be developed as a cash crop. Although the area is remote, there are plans to improve the highways to provide routes for marketing cash produce.

The system must continue to produce adequate subsistence crops, at least over the chosen planning horizon for the budget models. Thus, technological improvements are based on more efficient uses of resources in subsistence production and employing labor and other resources, as they become available, in cash crop production.

In this context, mechanization consists of introducing a form of improved hoe and a hand planter already approved by workers who have used them. During the budget model planning period, the people's diet has been improved by increasing bean production, and some increase in citrus consumption. Annual rates of crop attrition in storage are currently high (40-50 per cent); the introduction of improved storage cribs can reduce annual losses to 10 per cent.

Basic Assumptions

Assumptions are related to: attainable yields for subsistence and cash crops; crop prices; new required production levels for subsistence crops taking into account the annual rate of population increase and improved storage facilities; and improvements in labor efficiencies as the result of improved hand tools. Attainable crop yields are based on relevant experimental data from similar ecological zones; price assumptions are based on the local market and held constant for the budget model; sesame is introduced in the first operational year of the budget model (t=1); citrus orchards planted in this first operational year begin to yield in the fourth (t=4); improved varieties of subsistence crops are introduced in the sixth year (t=6).

In the initiating year, the case is a non-cash system. It is assumed that cash will be paid for work on cash crops, as they become established, the cash content of labor earnings increases over the budget period. To facilitate these improvements short-term loan facilities (i.e., crop loans and over-drafts), medium-, and long-term loan facilities are assumed, and general supervision of the system by a well qualified extension agent who can be responsible for 10-15 such villages.

Chilalo Awraja--Animal-powered Agriculture[1]

Chilalo Awraja (subprovince) is an area of small scattered family farms some 150 kilometers south of Addis

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[1]Appendix B.

Abeba on fairly fertile brown clay soil; the area lies between the elevation of 2,000-2,500 meters with a temperate climate. The case study establishes a typical family farm system which supports an average of 6.3 persons, producing a wide variety of crops and some livestock for subsistence and market exchange.

This case was selected as a system depicting an animal-powered agriculture, well established in Chilalo Awraja. Also, the area is in a state of economic transition. The Swedish International Development Agency has been operating a package development program (Chilalo Agricultural Development Unit) in the Awraja since 1967. Attitudes toward the modernization process are generally favorable. The use of engine-powered equipment is expanding through the development of a local tractor hire service. The area has a well established commercial economy although a substantial proportion of agricultural output is for family subsistence.

The System

There is one cropping season annually. Principal crops are wheat, barley, maize, flax, and beans which are both subsistence and cash crops; teff and peas are more generally grown for family consumption. Oxen plowing begins with the "small rains" in February and continues until the planting season, June-July. Hand weeding extends through the period August-November (the "big rains" begin in June). The harvest is gathered and stored during December and January. A variety of animals is also raised: cattle, oxen, sheep, goats, horses, mules, donkeys, and poultry.

A typical farm budget was prepared for 8.1 hectares of which 5.1 hectares is cropped in the initiating year. The average farm has 2.4 fragments.

Hiring workers for cash wages is a well established practice in the area. The typical family employs one resident laborer who receives wages in kind and cash. Some additional labor is hired as required at planting, weeding, and harvesting times. Population is quite concentrated in the area and cash wages tend to be low, about $0.05 (E$0.20) per man-hour.

Basis for Technological Improvement and Mechanization

Two alternative strategies are proposed to raise productivity and cash income. Strategy I is designed to introduce improved oxen, oxen equipment, and hand tools in order to improve efficiency in labor utilization and the quality of cultivations. At the same time recommended improvements in crop varieties and cultivation techniques are introduced. Strategy II is designed to introduce new crop varieties along with the facilities of a tractor hire service to improve quality and timeliness of cultivation techniques.

A substantial amount of farm output is required to satisfy domestic needs which have first priority in the farmer's planning. Surplus production is marketed. Economy in domestic requirements is effected by improved storage cribs on the farm.

Basic Assumptions

Assumptions are related to: attainable yields; crop prices; domestic crop requirements taking into account improved storage facilities; improvements in labor and animal efficiencies. Attainable yields are based on local research data on both variety trials and cultivation practices; price assumptions are based on the local market and held constant.

In the initiating year, the case is comprised of both cash and non-cash enterprises. The cash content increases over the planning period. To facilitate improvements short-term loans (crop loans and overdrafts), medium-, and long-term credit facilities are assumed. General supervisory services and storage facilities are assumed to be established for strategy I; additional capital requirements and personnel are assumed to operate a tractor hire service in strategy II.

Setit-Humera--Engine-powered Agriculture[1]

Setit-Humera is a remote area in the northwestern extremities of the Empire close to the Sudanese border approximately 750 kilometers from Addis Abeba. Soils are fertile vertisols. Water tends to be a limiting factor; the area receives annual mean precipitation of 615.4 mm. during the wet season, July-November. Elevation is around 600 meters, the climate is generally hot and fairly dry. Conditions are excellent for growing rainfed crops. This case depicts engine-powered private commercial agriculture.

The area has experienced rapid economic expansion during the past 10 years. Private entrepreneurs operate tractors and tractor equipment on large farms. Some 60,000 workers migrate into the area annually as farmers hire labor for planting, weeding, and harvesting. This recent rapid economic expansion has occurred without planning; current development of socio-economic infrastructure is totally inadequate.

The System

There is one annual cropping season. Principal crops are sesame, cotton, and grain sorghum (also a subsistence crop). Crops are planted at the beginning of the wet season, June, July, and August, after the land

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[1]Appendix C.

has been disced two or three times by wide-level disc harrow and tractor.

The average farm of 800 hectares is divided approximately into 45 per cent sorghum, 30 per cent sesame, and 25 per cent cotton in the initiating year. Approximately, 50-70 workers are hired on a farm of this size, depending on the crop distribution and seasonal requirements.

Crop production is quite sensitive to market price fluctuations. Following a substantial decline in 1967/68 sorghum prices there has been a significant swing to sesame and cotton as major cash crops. A good market exists for haricot beans which are introduced as another cash crop at the beginning of the budget period (t=1).

Crops are sold in Asmera, a haul of 430 kilometers east, or to local merchants. The absence of a bridge over the Tekeze River and extremely rough feeder roads necessitate double handling of much produce and consequent high transport and handling costs.

Basis for Technological Improvement and Mechanization

The level of mechanization is already established in this case but at recent levels of crop yields, general agricultural productivity has been very discouraging to further development. Two alternative strategies are employed in the budget models. Both incorporate improved cultivation practices and improved crop varieties in order to raise crop yields. The first strategy is designed to maintain the employment of manual labor at approximately the same or a slightly increasing level in view of the general economic objective of expanding employment opportunities. The second strategy is designed to make greater use of mechanization and consequently displaces relatively more labor.

Basic Assumptions

Assumptions are related to: attainable yields; crop prices; domestic requirements for sorghum and improved storage facilities; improved cultivation practices; labor and machine operating rates; the effect of constructing a bridge over the river. Little agronomic experimentation has been conducted in the area, assumptions for crop yields are based on relevant work from other similar sources. Crop prices are based on current observations and held constant for the budget model. Domestic requirements for grain sorghum are based on the man-days of work required; improved storage facilities are assumed to reduce waste from 15 to 3 per cent per annum. Improved cultivation practices, labor and machinery operational rates are based on data available from observations in the area.

Similar credit facilities are assumed. Supervisory and extension services are also assumed along with storage and marketing services. Plans for the construction of a bridge have been drawn up, therefore, transport and handling charges are reduced in the third operational year (t=3), by which time the bridge should be in use.

Tendaho Plantations--Engine-powered Agriculture[1]

Tendaho Plantations Share Company is a joint commercial venture between the agencies of the Imperial Ethiopain Government, private Ethiopain shareholders, and Mitchell Cotts and Company (Ethiopia) Limited. Total accumulated investment in 1967/68 amounted to $5,840,000 (E$14,600,000). This case depicts large-scale plantation farming using sophisticated engine-powered technology.

The plantations are located in the lower Awash Valley in the Danakil Desert about 580 kilometers northeast of Addis Abeba. The area lies at an elevation of 370 meters. The soil is extremely fertile when irrigated. Rainfall amounts to 100 mm. annually; under natural conditions the area is a flat, semi-hot desert.

The System

The climate affords a single annual crop of irrigated cotton which is of excellent quality. Cotton is planted in May, following three months of land preparation

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[1] Appendix D.

by tractor equipment. Weeding, irrigating, and cultivating take place during July-October, and picking (three times) lasts from December until February. The early tillage and cultivation operations are performed by tractor equipment, much hand labor is employed during the irrigation and weeding operations. There is a tremendous build-up of employed labor during picking, during the 1967/68 season approximately 5,600 people were employed in the fields.

In 1967/68 management consisted of seven expatriates and 30 Ethiopians. The expatriate staff is generally responsible for policy and administration assisted by Ethiopians who are also substantially responsible for general management duties.

The market for Tendaho cotton is adequate to absorb all its production. The quality of the fiber is excellent. It is anticipated that much cotton will be exported in the future but at present a substantial amount is sold in Addis Abeba, substituting for imported cotton.

Basis for Technological Improvements and Mechanization

The level of mechanization is already established. The basis for improvement and further mechanization lies in improvements in yield, improvements in operational efficiency, and enlarging the size of the operation.

Two strategies have been proposed. Strategy I is based on production and sale of raw cotton; strategy II is based on ginning raw cotton to sell cotton lint and seed. The second strategy involves the addition of a ginnery, which requires larger amounts of labor and capital.

No attempt is made to increase the level of mechanization. Plantation farming appears to have a unique opportunity to create employment which would be neutralized if all operations were fully mechanized.

Basic Assumptions

Assumptions are related to: inventory of capital equipment; prices and yields; costs for manual and machine operations.

Assumptions for cotton yield possibilities are based on achievable results in other similar areas. Experience at Tendaho has shown that annual increases in cotton yields can be anticipated. Some fertilizer and insecticide spray programs are incorporated into the assumptions.

There is clear evidence in the plantation's records of improvements in operational efficiency. These data are used in the development of labor and machine operational rates.

CHAPTER VI

ANALYSES OF SELECTED CASES BY BENEFIT-COST AND TREND TECHNIQUES

The details of the analyses are presented in this chapter under three main sections: benefit-cost analyses; analyses based on other criteria selected from development plans; and sensitivity analyses. The technique of benefit-cost analysis employs the financial data generated by the budget models, hence the criteria of this technique of analysis are measures of financial performance. Many important economic criteria of performance defy quantification in monetary units; consequently, those selected from Ethiopian development plans are treated separately rather than being assigned notional monetary values in order to incorporate them arbitrarily into the benefit-cost analyses. The sensitivity analyses employ the facilities of the benefit-cost analysis program to make crude estimates of the degree to which changes in levels of selected parameters cause changes in the magnitude of benefit-cost criteria. Such crude estimates, based on the gross adjustment of total outputs and total inputs, can be refined by making changes in assumptions specific to each crop included in the system, then recomputing the accounts for each particular budget model. Following the crude sensitivity analysis, the effect of price changes are evaluated by means of the last procedure.

Benefit-cost Analyses

Data from the benefit-cost analyses are contained in Table 14 which contains two major divisions: analyses of data generated directly from the budget models (t=0, ...,10) and analyses of 20 year approximations (t=0,...,20). Within each division the seven criteria of financial performance are presented by case for high and low production levels. For Agnale and Chilalo two separate runs[1] are employed. Both these cases were observed to devote a considerable proportion of available resources to subsistence production. Without any change in the level of agricultural technology, it is reasonable to assume that

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[1]The term run is employed to designate a computer run in which the second run (run 2) is used to analyze data in some way modified from the data used in the original analysis (run 1). The data included in run 1 incorporate all the data generated by the budget models while the input and output data for the subsistence production of the initiating year (t=0) are excluded from run 2. Thus, the analyses employing run 2 data exclude production resulting from investment which took place before the budget period. Essentially this form of analysis takes into account the effects on the agricultural system of changes in level of technology and avoids the problem of including production due to investment not taken into account which inflates the results. This separation constitutes the process of analysis "with and without" the project.

TABLE 14 Financial performance criteria from benefit-cost analyses of budget data (t=0,...,10) and 20 year approximations (t=0,...,20) at high (H) and low (L) production levels by case using constant prices and 10 per cent discount rate, Ethiopia

Case	Strategy (run)[c]	Sum $PVTR_L$[a] ÷ Sum $PVTR_H$	Sum $PVTC_L$[b] ÷ Sum $PVTC_H$	Computed values for benefit-cost criteria: Net present value		Payback		Internal rate of return		Benefit-cost ratio		NPV/K		NPV/T_W		NPV/T_{WS}	
				H	L	H	L	H	L	H	L	H	L	H	L	H	L
		-----dollar ratios-----		--------dollars[d]--------		---year---		---per cent---		-----dollar ratios-----							
Analyses of budget data (t=0,...,10)																	
Agnale	- (1)	.728	.986	46,521	25,834	<1	<1	>400	>400	2.50	1.84	7.57	4.21	22.89	12.71	12.54	6.96
	- (2)	.535	.960	34,840	14,154	5	7	61.1	38.0	4.30	2.40	5.67	2.30	17.14	6.96	9.39	3.81
Chilalo	I--oxen (1)	.609	.749	1,211	-102	4	>10	39.7	6.0	1.20	0.98	1.37	-0.12	4.33	-0.36	2.92	-0.25
	II--tractor hire (1)	.592	.805	586	-1,288	8	>10	21.8	< 0	1.08	0.79	0.48	-1.06	0.60	-1.32	0.40	-0.89
	I--oxen (2)	.559	.717	1,661	-252	5	>10	35.3	< 0	1.20	0.93	1.20	-0.28	3.90	-0.90	2.55	-0.61
	II--tractor hire (2)	.544	.786	435	-1,439	8	>10	18.4	< 0	1.06	0.74	0.36	-1.18	0.45	-1.48	0.30	-0.99
Setit-Humera	I--labor intensive	.893	.977	110,827	47,818	4	6	51.0	32.2	1.18	1.08	2.75	1.19	181.79	78.43	123.55	53.51
	II--machine intensive	.896	.977	162,936	100,372	3	4	57.9	45.8	1.29	1.18	2.61	1.61	267.27	264.64	181.65	111.90
Tendaho	I--raw cotton	.591	.921	1,853,883	-3,224,946	9	>10	18.7	< 0	1.14	0.73	0.51	-0.89	1.74	-3.02	1.08	-1.89
	II--ginned cotton	.590	.938	4,800,562	-2,497,702	7	>10	28.7	< 0	1.31	0.83	1.23	-0.64	3.45	-1.98	2.36	-1.31
Analyses of 20-year approximations (t=0,...,20)																	
Agnale	- (1)	.740	.992	105,705	67,766	<1	<1	>400	>400	3.54	2.64	16.44	10.55	36.64	23.50	20.63	13.23
	- (2)	.635	.977	90,147	52,271	5	7	64.1	44.8	7.24	4.71	14.02	8.13	[illegible]	18.12	17.60	10.20
Chilalo	I--oxen (1)	.587	.719	2,355	226	4	13	41.9	14.4	1.27	1.04	2.21	0.22	5.92	0.57	4.07	0.39
	II--tractor hire (1)	.570	.787	1,684	-1,412	8	>20	27.0	< 0	1.15	0.84	1.06	-0.89	1.22	-1.02	0.83	-0.70
	I--oxen (2)	.542	.686	2,156	38	5	18	38.0	10.7	1.28	1.01	2.02	0.04	5.42	0.10	3.72	0.07
	II--tractor hire (2)	.529	.768	1,481	-1,612	8	>20	24.3	< 0	1.15	0.79	0.93	-1.02	1.07	-1.17	0.73	-0.80
Setit-Humera	I--labor intensive	.863	.969	229,437	115,098	4	6	53.0	36.3	1.28	1.14	4.73	2.37	265.10	132.99	183.11	91.85
	II--machine intensive	.868	.967	310,160	194,577	3	4	59.1	47.6	1.41	1.27	4.24	2.66	358.36	224.82	247.53	[illegible]
Tendaho	I--raw cotton	.561	.888	10,801,574	-637,999	9	>20	28.8	8.2	1.53	[illegible]	2.64	-0.16	[illegible]	-0.39	4.40	-0.26
	II--ginned cotton	.309	.915	17,311,951	-9,748,080	7	>20	36.1	< 0	1.70	0.57	3.97	-2.24	7.42	-4.80	5.51	-3.43

[a]Present Value Total Revenue (H = high level production; L = low level production).

[b]Present Value Total Costs.

[c]Run number in parenthesis following strategy; in the case of Agnale there is only one strategy but two runs. Run 1 consists of analyses of all data. Run 2 data are less original subsistence outputs and inputs.

[d]Dollar values for these analyses are all U.S. dollars.

production continues at the established level observed in the initiating year. Technological improvements facilitate the simultaneous expansion of cash crop production and both the more efficient production of subsistence requirements and the expansion of these requirements to meet the needs of an increasing population.

Run 2 data for Agnale and Chilalo constitute a "with and without the project" approach to these two cases. In Setit-Humera and Tendaho the separation of effects "with and without the project" is unnecessary as all production is accounted for by the initial investment. Since run 2 data afford a more accurate representation of the Agnale and Chilalo cases, following the first benefit-cost analyses only run 2 data are examined.

Obtaining the results of assumptions for high- and low-level yields has necessitated the processing of two sets of assumptions through the budget models. The relationships between high and low production levels for each case essentially represent the results of a sensitivity analysis. Hence, the ratios of total revenue to total cost are included in the tabulated data.[1]

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[1]Since the discounting elements occur in both numerator and denominator of the fractions $PVTR_L/PVTR_H$ and $PVTC_L/PVTC_H$, these ratios are equivalent to the relative size of outputs (TR) and inputs (TC) for high and low levels of production. Thus, if $PVTR_L/PVTR_H = .728$ and $PVTC_L/PVTC_H = .986$, the true effect in the budget models of a reduction of 27.2 per cent (1.00 - .728) in total revenue, due to some combination of yield and price

Net Present Values

The NPV, which is a measure of the present value of anticipated net operating surplus to a project, serves to indicate the relative size of projects at a given discount rate (0.10). Computed values for NPVs are presented in Table 14. In the four cases under consideration positive NPVs are indicated for all high production levels but at low levels the data from Chilalo and Tendaho cases indicate negative NPVs. Thus, there are critical levels of return in these projects below which costs exceed returns.

Payback Periods

The NPVs of all cases at high production levels are positive and, therefore, all PBs fall within the planning period of 10 years. Where NPVs are negative for several cases at the low production level within the 10 year planning period, the PB is assumed to be greater than 10. In the two instances of oxen power in Chilalo (strategy I, run 1 and strategy I, run 2), NPVs become positive within the 20 year period, i.e., $10 < PB < 20$. In instances where returns for investment can be expected

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declines, is a reduction of 1.4 per cent (1.00 - .986) in inputs.

Alternatively, these fractions may be used to approximate the effect of an overall reduction in revenue amounting to 25.8 per cent (1.00 - .728) - (1.00 - .986). However, this is a crude estimate which does not take into account adjustments in the level of inputs which occur in the budget model when total output is reduced.

within the same year as investment costs occur, or financial arrangements for the repayment of loans are such that project costs never exceed returns, the situation is indicated by PB < 1.

Internal Rates of Return

The IRR is the discount rate which reduces the NPV to zero and measures the rate of return to investment in the project. If $i_o - i > 0$ then the project can be expected to repay capital investment costs and pay a return to investors above the market rate of interest. The benefit-cost program is limited to a maximum IRR of 400 per cent which was encountered only in run 1 data for Agnale. When these data are re-analyzed on the basis of "with and without" the project, a more plausible IRR is obtained. The IRR ceases to be a useful criterion when its value becomes negative since then the project must also <u>receive</u>, rather than <u>pay</u>, an interest rate. Such a situation is implausible so the result has been recorded as IRR < 0.

Benefit-cost Ratios

The computation of the conventional B/C employs the same elements as those used in the computation of the NPV. Thus, when NPV $\geq$ 0, B/C $\geq$ 1 and when NPV < 0, B/C < 1. The data in Table 14 are consistent with these conditions.

Modified Benefit-cost Ratios

Three other ratios were computed: NPV in relation to capital investment costs (NPV/K); NPV in relation to the salary costs for professional technical personnel (NPV/T_W); and NPV in relation to salaries and costs of supporting services for professional technical personnel (NPV/T_{WS}). The use of these three ratios carries the implication of the relative scarcity of these three selected resources: capital (K), salaries to technical personnel (T_W), supporting facilities to technical personnel (T_{WS}).

NPV in Relation to Capital Costs

NPV/K estimates anticipated average net returns per unit of investment capital when the entire anticipated net operating surplus is allocated to the one arbitrarily selected scarce resource of capital. The data in Table 14 indicate possibilities of NPV/K > B/C and NPV/K < B/C. The relationships between NPV/K and B/C can be understood from the following argument:

1. $\frac{NPV}{K} = \frac{(B - (0 + K)}{K},$

where B = discounted total benefits,

0 = discounted total operating costs,

K = discounted total capital costs.

$$= \frac{B - 0}{K} - 1$$

$$\frac{NPV}{K} + 1 = \frac{B - 0}{K}.$$ [1]

2. $$B/C = \frac{B}{0 + K}$$

3. $$\frac{B - 0}{K} > \frac{B}{0 + K} \text{ if, and only if } \frac{B}{0 + K} > 1;$$

$$\frac{B - 0}{K} < \frac{B}{0 + K} \text{ if, and only if } \frac{B}{0 + K} < 1;$$

$$\frac{B - 0}{K} = \frac{B}{0 + K} \text{ if, and only if } \frac{B}{0 + K} = 1.$$

Therefore, if $B/C > 1$ then $NPV/K + 1 > B/C$ and if $B/C < 1$ then $NPV/K + 1 < B/C$. These conditions are satisfied by all the computed values for B/C and NPV/K contained in Table 14.

<u>NPV in Relation to Salary Costs for Technical Personnel</u>

NPV/T_W estimates the anticipated average returns for the one arbitrarily selected scarce resource of professional technical personnel when only salary costs (T_W) are taken into account. The data in Table 14 indicate possibilities of $NPV/T_W > NPV/T_{WS}$ and $NPV/T_W < NPV/T_{WS}$.

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[1] $\frac{B - 0}{K}$ is the concept of profitability ratio used by Little and Mirrlees with the exception that taxation (T) on inputs is also accounted for, thus: $PR = \frac{B - 0 - T}{K}$. Little and Mirrlees, *op. cit.*, p. 96.

NPV in Relation to Salary and Supporting Costs for Technical Personnel

Since professional technical personnel are unable to operate in the field without certain facilities in addition to their salaries, these additional costs have been included in the cost (T_{WS}) of employing technical personnel. NPV/T_{WS} estimates the anticipated average returns for this one composite of arbitrarily selected scarce resources. The computed values for these two ratios satisfy the following conditions: $T_{WS} > T_W$, therefore when NPV > 0, NPV/T_W > NPV/T_{WS}; however, when NPV < 0, NPV/T_W < NPV/T_{WS}.

Analyses of Case Study Data

The benefit-cost analysis technique affords a means of obtaining quantified measures of the financial potential for selected cases. The discussion in this section attempts to interpret the analyses for each case and the underlying suitability of the selected agricultural systems to accommodate the proposed changes. Thus, the results of the benefit-cost analyses are used in this thesis primarily to show qualitative differences between selected cases rather than to effect a selection process by which projects are either accepted or rejected.

Agnale

Clearly, the financial potential of introducing appropriate technological improvements into the productive system of Agnale Village is high. This is demonstrated by relatively high computed values for NPV (at 10 per cent discount rate), high B/Cs, and high modified benefit-cost ratios. Analysis of run 1 data indicates IRR > 400.

The analyses of the 20 year approximations make the investment potential for Agnale appear even more favorable because citrus yields are continuing to increase beyond the tenth operational year of the budget. Over the 20 year period NPVs are approximately three times greater than over the budget period, B/Cs and modified B/Cs are approximately two to three times as great.

The computed values for IRRs suggest that the rate of return to investment in Agnale can be anticipated to be higher than in all other cases at high production levels, higher than all other cases except Setit-Humera, strategy II (machine intensive) at low production levels where the difference is small. IRRs are also high and positive for the low production level assumptions. The relationships between NPVs and IRRs for high and low production levels using run 2 data are illustrated in Figure 4. The figure demonstrates that expectations of relatively high net returns are legitimate for appropriate investments in the Agnale system using any reasonable discount rate whether high or low level yields are anticipated.

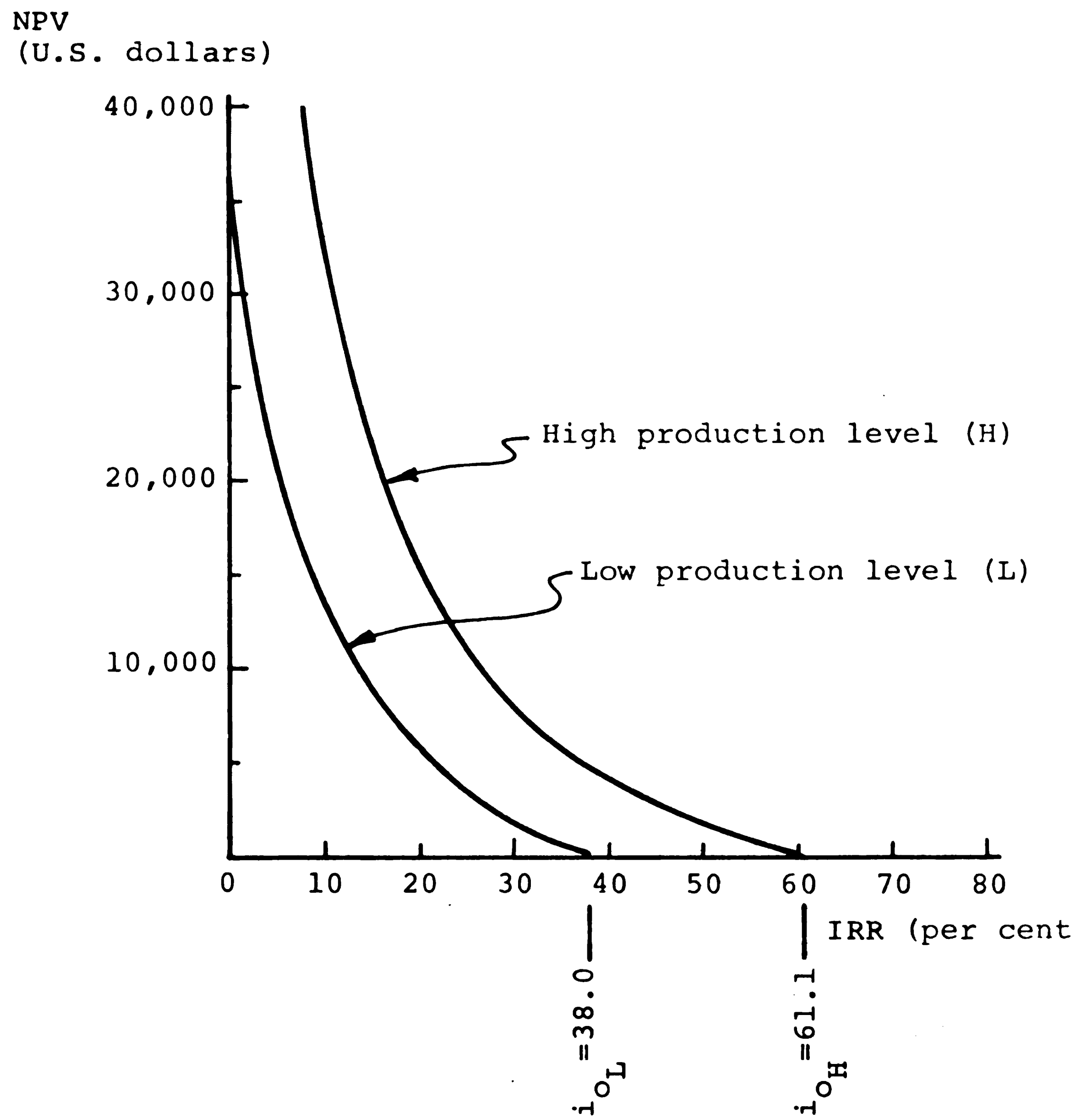

FIGURE 4 Agnale: Relationship between net present value (NPV) and internal rate of return (IRR) for high and low production levels in budget data (t=0,...,10; run 2)

At high production levels for run 2 data, anticipated net returns to total investment approach six times the costs of investment over the budget period and about 14 times over the 20 year approximation. Net returns for technical personnel approach 17 times the cost of salaries over the budget period; 31 times over the 20 year approximation. When supporting costs are included, these anticipated net returns for costs of technical personnel decrease to about 9 for the budget period and to about 17 for the 20 year approximation.

Improvements in the level of mechanization and concomitant technological improvements are suggested as appropriate to the Agnale system are quite unsophisticated. Due to the level of understanding of the people, the level of essential technical skills was assumed to be that which a single extension agent can provide. Thus, initiating the system from relatively low levels of productivity and introducing new capital equipment which is relatively inexpensive, the potential for improving total benefits by moving the system toward cash crop production appears to be high.

Chilalo

The financial potential of the productive system represented by the budget model from the Chilalo case presentes less attractive investment prospects than either the Agnale or Setit-Humera case. This situation is demonstrated by relatively low NPVs, B/Cs, and modified B/Cs several of which have negative values.

The analyses of the 20 year approximations suggest a somewhat more favorable situation for the longer planning horizon. During this period two NPVs become positive along with their six associated B/Cs. Furthermore, the longer planning horizon is useful since PBs of less than 20 years for two out of the four which are greater than 10 years.

Two strategies are incorporated into the budget model. Strategy I provides for the utilization of improved oxen and oxen equipment in contrast to strategy II in which a tractor hire service is employed. The analyses of run 2 data in both the budget period and the 20 year approximation indicate strategy II to be a less attractive investment proposal than strategy I.

These results suggest that the Chilalo case is unlikely to appear favorable in comparison with other cases. Within the Chilalo case study, in both strategies, there appears to be a critical level of yield assumptions below which net negative returns can be anticipated. This critical level is indicated by the point at which B/C becomes less than unity.[1]

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[1]The sensitivity analyses have been employed to determine this critical level. Data are tabulated in Appendix G.

The computed values for IRRs indicate high rates of return relative to market interest rates for investments provided that high level yields are realized. However, IRRs of Agnale and Setit-Humera cases are considerably higher than IRRs for Chilalo. Furthermore, under assumptions of low-level production, IRRs are negative although the IRR for strategy I, low level, is positive in the 20 year approximation. The relationships between NPVs and IRRs using run 2 data, are illustrated in Figure 5. The figure demonstrates that expectations of only modest anticipated net returns are legitimate in this case using reasonable discount rates.

Anticipated net returns to total investments are small, $NPV/K > 1$ only in strategy I, high production level (run 2 data) which suggest some considerable uncertainty about expectation of adequate returns from investments. Average net returns for costs of technical personnel appear to be adequate in strategy I but not in strategy II (where $NPV/T_W < 1$ and $NPV/T_{WS} < 1$) in the budget analyses although $NPV/T_W > 1$ (1.07) in the 20 year approximation.

The potential for mechanization and technological improvement does not appear to be high in the Chilalo case. Two important observations emerge from these analyses: firstly, that production levels are critical in determining whether positive or negative net returns

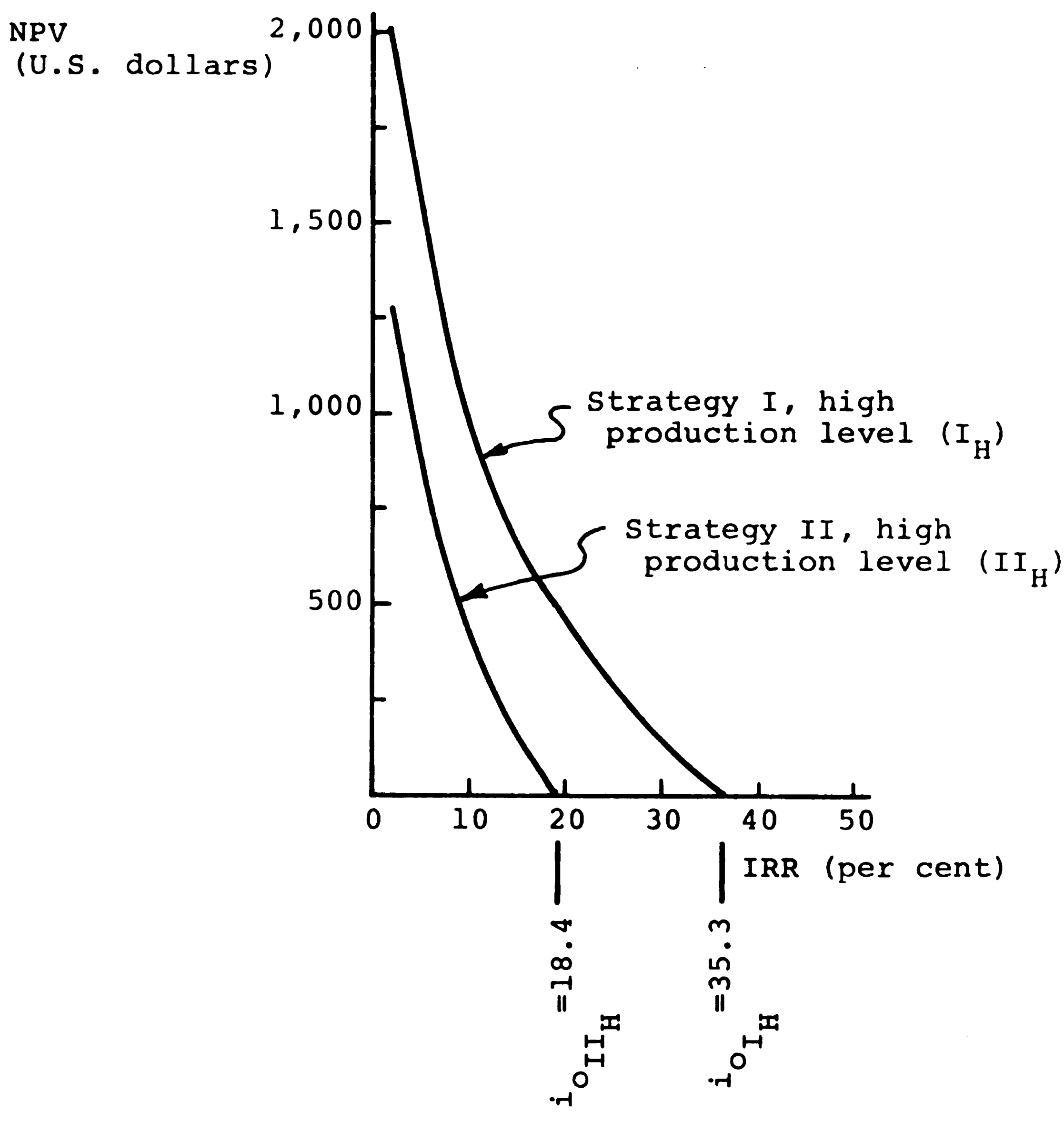

FIGURE 5 Chilalo: Relationship between net present value (NPV) and internal rate of return (IRR) for high production levels in strategies I and II of budget data (t=0,...,10; run 2)

can be expected; secondly, that strategy I appears much more promising than strategy II.

Assumptions for strategy I (oxen) enable extension facilities (the costs and services for technical personnel) to be more extensively employed than assumptions for strategy II (tractor hire): in strategy I the unit[1] of extension facilities were assumed to be spread over 150-200 farmers in contrast to the extension and tractor hire service of strategy II, spread only over 50 farmers. These assumptions illustrate the importance of spreading facilities of capital intensive services over a large number of farm units. This appears to be particularly important in areas where farm structure and/or current farming practices have not yet reached the level of development compatible with the utilization of sophisticated engine-powered equipment.

Setit-Humera

Benefit-cost analyses demonstrate a high financial potential for all aspects of the Setit-Humera case study. NPVs are high and positive using the 10 per cent discount rate; B/Cs and modified B/Cs are all greater than unity. When the costs of technical personnel are considered as the scarce factor, reference to Table 14 reveals

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[1]These are the annual costs for additional personnel, equipment, and supporting costs shown in Table B.12.

that the computed values for NPV/T_W and NPV/T_{WS} are extraordinarily high. These high values for NPV/T_W and NPV/T_{WS} relative to the values for NPV/K are because expenditures for technical personnel are modest in relation to total capital investment costs which are relatively high. Furthermore, the employment of technical personnel was assumed to be spread over 100 farmers. Thus, a modest expenditure on salaries and supporting services is spread over the expected net returns of some 80,000 hectares. This situation contrasts to that of Tendaho Plantations in which both capital investments and the costs of technically qualified professional personnel are extremely heavy; these costs are spread over the expected net returns from a maximum of 10,000 hectares. Consequently, for Tendaho B/Cs and modified B/Cs are relatively much smaller at the same discount rates.

Differences between the values of IRR computed from the budget data and 20 year approximations are small. Since PBs are the same in both analyses, these results suggest that when the introduction of appropriate technological improvements into the Setit-Humera case causes net returns (i.e., $NPV \geq 0$) to reach the break-even point, relatively high rates of return can be expected. Replacement of depreciated capital perpetuates the continuing high rate of return for investment rather than causing any material change to anticipated returns over the longer period of the analysis. The relationships between NPVs and IRRs are illustrated in Figure 6. This figure demonstrates extremely high NPVs associated with low discount rates.

Farm structure of the Setit-Humera case is appropriate to make economical use of expensive equipment; economies of scale are demonstrated in the high rates of expected net returns to investment. Under these conditions it appears that technical personnel can also be employed extensively with consequent high anticipated net average returns for this scarce resource.

The profitability of operations from the individual farmer's viewpoint is clearly influenced by the level of attainable yields. From the aspect of long-term investment decisions, however, even the low level yield assumptions employed in these analyses lead neither to negative IRRs nor negative NPVs. Furthermore, neither B/Cs nor modified B/Cs are below unity. These are important considerations which favor decisions to make long-term investments in such an area of enterprise.

<u>Tendaho</u>

The analyses demonstrate high positive NPVs for high production levels in both strategies. However, NPVs are high and negative for low production levels in both strategies. These results suggest that yield attainments

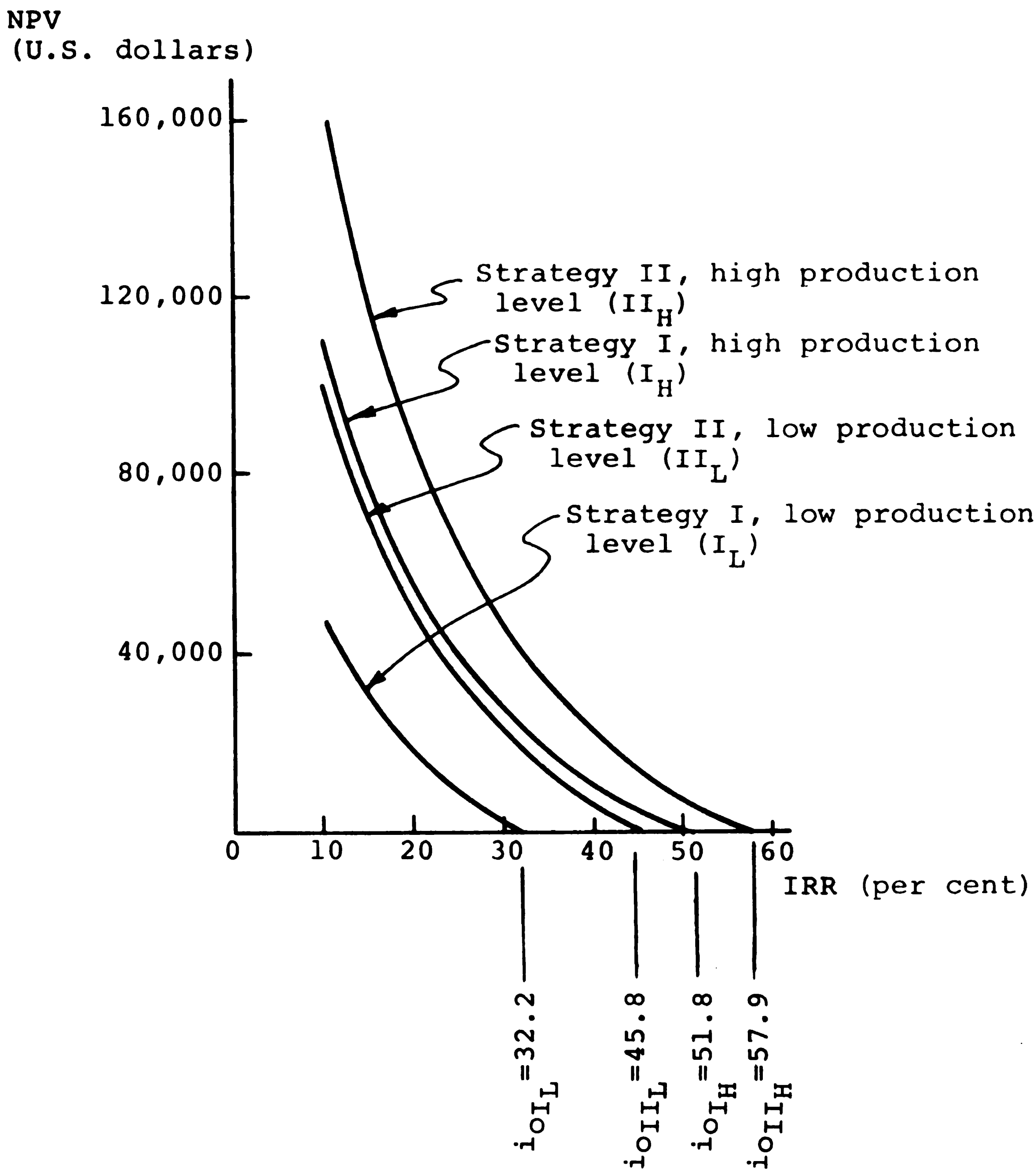

FIGURE 6 Setit-Humera: Relationship between net present value (NPV) and internal rate of return (IRR) for high and low production levels in strategies I and II of budget data (t=0,...,10)

are critical in establishing the plantations and caution should be exercised in making decisions to proceed with an investment proposal of this nature and magnitude if adequate yield achievements are uncertain. From the analysis of strategy I (raw cotton) low level production, a break-even point at which NPV will become positive is clearly indicated by the shift in value of NPV as the period of analysis is extended from 10 to 20 years, however, the PB period is greater than 20.

Expected average net returns to investment costs and professionally trained personnel are moderately high for high production levels but are negative for low levels due to NPV < 0. The computed value for these criteria of returns to selected scarce resource (NPV/K, NPV/T_W, and NPV/T_{WS}) are not particularly high, probably because of the extremely large amount of capital investment involved, especially in the early stages when establishment costs are high and the productive area is only a fraction of the whole concession. Improvements in the financial potential of the plantations are reflected in the substantial increase in the values of NPV/K, NPV/T_W, and NPV/T_{WS} for the analyses of 20 year approximations in contrast to their values in analyses of budget data. Nevertheless, heavy capital expenditures, a relatively large number of technically trained personnel, and relatively high costs for supporting services to these personnel result in adequate but not high returns to these scarce resources when yields are satisfactory.

Computed values for IRR for high production levels are considerably higher than the selected discount rate so that an adequate rate of return for investment can be anticipated. IRRs are negative, however, for low levels although in the analyses of the 20 year approximation, the low level strategy I IRR becomes positive, but small. This shift in sign for IRR suggests that, over the longer period, strategy I can be expected to break even on net returns only if the market rate of interest were lower (i.e., 8.2 per cent) than the discount rate assumed for these analyses (i.e., 0.10). The relationships between NPVs and IRRs are illustrated in Figure 7. This figure also demonstrates the relationships among high and low levels of production for each strategy and the way in which the curve for strategy I (raw cotton) low level, shifts to the right (the dashed line) in the analyses of 20 year approximations resulting in IRR > 0.

Tendaho Plantations case study depicts a large-scale engine-powered operation in which capital investment costs and the costs of technically trained professional personnel, both to employ and to maintain in the field, are high. Thus, rates of return for capital and antici-pated average net returns to scarce resources are not

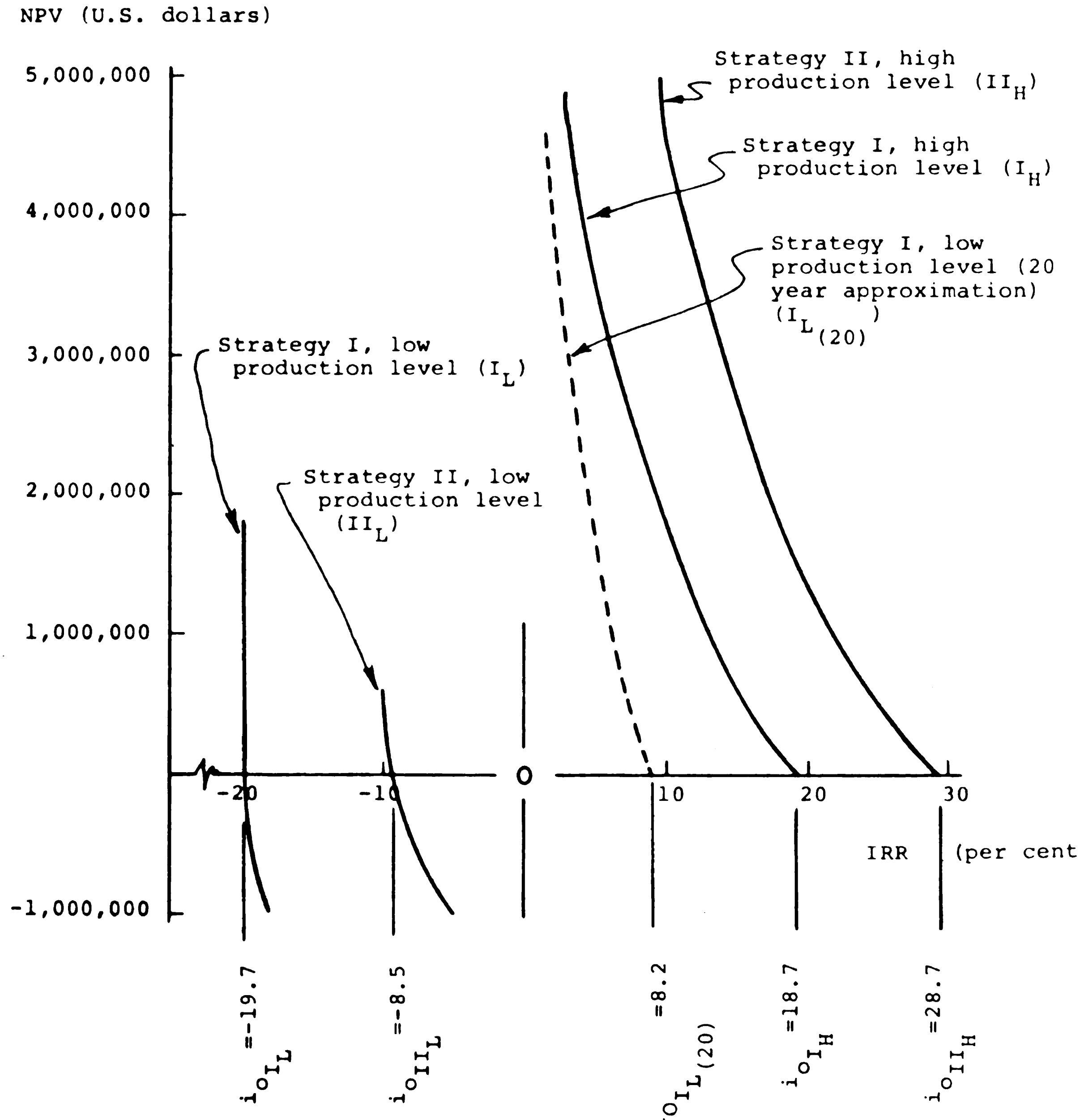

FIGURE 7 **Tendaho: Relationships between net present value (NPV) and internal rate of return (IRR) for high and low production levels in strategies I and II of budget data (t=0,...,10) and for low production level in strategy I of 20 year approximations (t=0,...,20)**

particularly high even though the total size of operation and anticipated net returns are large under assumptions of high level production. Under low level production assumptions these anticipated net returns are large and negative.

Case Ranking According to Benefit-cost Criteria

The criteria of benefit-cost analysis have been used to demonstrate the relative effects on selected productive systems when appropriate improvements in technology are introduced. However, since one of the main uses of the benefit-cost analysis technique is to rank projects according to one of the criteria, the ranking of the four cases can be considered at this juncture. The data contained in Table 15 places each production level of the case studies in order of rank according to each criterion on a scale of 7.[1]

Using NPV as the criterion it is clear from these data that relative size of operation has an important bearing on rank. Tendaho ranks first and second (strategies II and I), Setit-Humera third and fourth (strategies II and I) in both sets of analyses for high levels of production. At low levels of production Setit-Humera moves into first and second position and Tendaho into

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[1] Two strategies in Chilalo, Setit-Humera, and Tendaho cases, one strategy in Agnale case. Wherever two cases are equal for a position of rank, they are assigned the same number and the following position of rank is omitted.

TABLE 15 Ranks according to benefit-cost criteria from analyses of budget data (t=0,...,10) and 20 year approximations (t=0,...,20) at high (H) and low (L) production levels by case, Ethiopia

Case	Strategy (run)[a]		Case rank according to value of criterion indicated													
			NPV		PB		IRR		B/C		NPV/K		NPV/T_W		NPV/T_{WS}	
			H	L	H	L	H	L	H	L	H	L	H	L	H	L
			rank													
			Analyses of budget data													
Agnale	-	(2)	5	3	3}[b]	3	1	1	1	1	1	1	3	3	3	3
Chilalo	I--oxen	(2)	6	(4)[c]	3}	4}	4	(4)}	4	4[d]	5	(4)	4	(4)	4	(4)
	II--tractor hire	(2)	7	(5)	6	4}	7	(4)}	7	6[d]	7[d]	(7)	7[d]	(5)	7[d]	(5)
Setit-Humera	I--labor intensive		4	2	2	2	3	3	5	3	2	3	2	2	2	2
	II--machine intensive		3	1	1	1	2	2	3	2	3	2	1	1	1	1
Tendaho	I--raw cotton		2	(7)	7	4}	6	(4)}	6	7[d]	6[d]	(6)	6	(7)	6	(7)
	II--ginned cotton		1	(6)	5	4}	5	(4)}	2	5[d]	4	(5)	5	(6)	5	(6)
			Analyses of 20 year approximations													
Agnale	-	(2)	5	3	3}	3	1	2	1	1	1	1	3	3	3	3
Chilalo	I--oxen	(2)	6	4	3}	4	4	4	5}	4	6	4	6	4[d]	6	4
	II--tractor hire	(2)	7	(5)	6	5}	7	(6)	7	6[d]	7[d]	(6)	7	(6)	7[d]	(6)
Setit-Humera	I--labor intensive		4	2	2	2	3	3	5}	3	2	3	2	2	2	2
	II--machine intensive		3	1	1	1	2	1	4	2	3	2	1	1	1	1
Tendaho	I--raw cotton		2	(6)	7	5}	6	5	3	5[d]	5	(5)	5	(5)	5	(5)
	II--ginned cotton		1	(7)	5	5}	5	(6)	2	7[d]	4	(7)	4	(7)	4	(7)

[a]Run number in parenthesis following strategy. [b]Bracket indicates equal ranking with one or more other cases.

[c]Parenthesis indicates negative value for ranking criterion. [d]Ratio < 1.0.

sixth and seventh because of large negative NPVs for low yield assumptions in the Tendaho case.

The PB used as a ranking criterion indicates that break-even point on investments may be anticipated first in the Setit-Humera case: 4-6 years in strategy I for high and low production levels, 3-4 years in strategy II. Agnale follows showing 5-7 years for high and low production levels.

The relative positions in rank shift in using criteria based on rates of return and average net returns to scarce resources. Using IRR as the criterion, Agnale moves into the high position, Tendaho moves to a relatively low position, and Setit-Humera takes second and third positions. The relative high order of rank is maintained for Setit-Humera and Agnale throughout the use of these criteria for ranking.

The benefit-cost ratios indicate Agnale to be consistently high, ranking in the first position. Tendaho (strategy II: ginned cotton) is higher than Setit-Humera (strategy II: machine intensive) for high production levels but for low production levels, Setit-Humera occupies second and third positions.

There is a considerable degree of consistency between the orders of rank when modified B/Cs are used as ranking criteria. Using NPV/K, average net returns to invested capital can be anticipated as highest in Agnale, second and third in Setit-Humera for both high and low levels of production, and for both the analyses of budget data and the 20 year approximations. These orders are reversed using NPV/T_W and NPV/T_{WS} as ranking criteria: Setit-Humera occupying first and second position and Agnale third. It should be noted that using these last two criteria, the cases occupying positions 1-3 remain unchanged with either a change in criterion or a change in production level. For the other cases, change in criterion has no effect on ordering but there is a re-arrangement between high and low levels of production.

The results of benefit-cost analyses are useful in assessing the potential financial performance of the case studies. Previous discussion has illustrated that using financial criteria is only one aspect in judging the potential value of an investment proposal. The next section of this chapter takes these other economic aspects into account.

Analyses Based on Other Criteria Selected from Development Plans

The data contained in the ensuing four tables, are the results of measuring other economic quantities of importance in the overall development of national economic plans. These quantities were not incorporated into the benefit-cost analyses because each one is a specific criterion for which specific quantified information tends to be more useful than the single number measure for values or ratios which the benefit-cost technique affords.

Generation of Income

The data presented in Table 16 show the relative increases in gross and net incomes for each case; these data are not expressed relative to each other, however, since a common base is not used to compute these indices.[1] The percentage cash relates to the cash component in each of the incomes.

The data for Agnale indicate that gross incomes increase some 5-6 times (high production level) over the budget period and net incomes approximately 14 times. The greater increase in net incomes is due to relatively low input costs which do not increase as rapidly as output revenues. Over the budget period cash content of incomes increases from zero to almost 80 per cent.

The increase in gross incomes for Chilalo is similar to that for Agnale although the relative size is much smaller in Chilalo. Net incomes for Chilalo also increase in similar proportions in high production levels

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[1]For relative sizes of incomes between cases the employed index bases (t=0) are as follows: gross income, (1) Agnale, $4,497, (2) Chilalo, $330, (3) Setit-Humera, $69,197, (4) Tendaho, $141,680; net income, (1) Agnale, $1,567, (2) Chilalo, $37, (3) Setit-Humera, -$6,352, (4) Tendaho, -$440,872.

TABLE 16 Indices of annual gross income and annual net income at three points in budget period (t=1,5,10), and included cash percentage by case, Ethiopia

Case	Strategy	Pro-duction level	Annual gross income at indicated year: Index 1	Index 5	Index 10	Percentage cash 0	Percentage cash 1	Percentage cash 5	Percentage cash 10	Annual net income at indicated year: Index 1	Index 5	Index 10	Percentage cash 0	Percentage cash 1	Percentage cash 5	Percentage cash 10
			t_o=100			per cent				t_o=100			per cent			
Agnale	-	H	102.4	274.1	568.4	-	1.5	61.2	79.7	121.5	531.7	1,409.4	-	0.9	60.9	79.7
		L	102.4	182.1	375.5	-	1.5	42.2	69.9	121.5	254.8	842.1	-	0.9	19.7	69.2
Chilalo[a]	I--oxen	H	162.4	385.2	495.2	64.5	78.9	86.9	89.8	71.7	945.0	1,388.9	75.7	(363.4)[b]	83.8	89.0
		L	121.5	217.6	269.1	64.5	58.4	76.7	81.2	(97.6)[c]	(442.2)[c]	[illegible]	75.7	(25[illegible].6)[b]	(134.6)[b]	54.1
	II--tractor hire	H	174.6	446.7	566.1	64.5	82.4	93.1	94.6	27.6	1,087.6	1,[illegible].6	75.7	(353.4)[b]	88.5	92.2
		L	125.8	244.6	301.8	64.5	75.5	87.4	89.8	(208.0)[c]	(1,267.2)[c]	(1,396.3)[c]	75.7	(160.2)[b]	(109.9)[b]	(109.0)[b]
Setit-Humera	I--labor intensive	H	119.6	156.5	199.8	83.7	90.5	92.3	93.7	(174.6)[c]	452.4	838.7	86.6	(99.0)[b]	100.5	100.3
		L	117.1	134.3	161.3	83.7	90.4	91.4	99.2	(195.1)[c]	(11.3)[c]	447.8	86.6	(9[illegible].1)[b]	(83.6)[b]	100.5
	II--machine intensive	H	119.7	159.9	202.5	83.7	92.9	93.9	94.8	(63.5)[c]	582.6	981.2	86.6	(97.9)[b]	100.3	100.2
		L	117.2	139.8	163.3	83.7	92.7	93.2	94.1	(84.7)[c]	409.2	629.1	86.6	(98.4)[b]	100.5	100.3
Tendaho	I--raw cotton	H	281.2	1,453.5	4,870.2	100.0	100.0	100.0	100.0	(207.1)[c]	(291.3)[c]	123.4	100.0	100.0	100.0	100.0
		L	232.0	881.9	2,597.4	100.0	100.0	100.0	100.0	(220.2)[c]	(421.3)[c]	(485.6)[c]	100.0	100.0	100.0	100.0
	II--ginned cotton	H	369.2	1,966.1	6,587.8	100.0	100.0	100.0	100.0	(208.8)[c]	(265.6)[c]	263.9	100.0	100.0	100.0	100.0
		L	304.6	1,192.9	3,513.5	100.0	100.0	100.0	100.0	(224.4)[c]	(413.4)[c]	(422.0)[c]	100.0	100.0	100.0	100.0

[a] All indices have been computed before taxation for Chilalo.

[b] Parentheses denote negative values: negative cash percentage indicates farmer has borrowed to meet cash obligations.

[c] Parentheses denote negative values.

of both strategies. In the low production levels, however, negative net returns are anticipated until the eighth year in strategy I (oxen) and over the entire budget period in strategy II (tractor hire). The cash content of incomes shows only modest increases since the system is already integrated into a market economy.

In the case of Setit-Humera, increases in gross incomes are modest although the increase in net incomes is greater than eight times over the budget period. Furthermore, over this time period net incomes in strategy I (labor intensive) shift from a negative value in the initiating year to positive values after the fourth year for high production levels and after the sixth year for low levels. Increases in cash contents are small since the system is already operating as a cash economy in the initiating year.

The data for Tendaho indicate substantial increases in gross but only modest increases in net incomes. It should be borne in mind that part of these increases is due to substantial increases in area under cultivation over the budget period. Net incomes for low production levels remain negative throughout the budget period. The plantations are organized completely as a cash economy, therefore, there is no change in cash content of the accounts.

Since the data contained in Table 16 are derived from the budget models, an analytical view of each case is presented in terms of gross and net annual incomes from the point of view of the individual operator within the farm system. This point of view is important because the operator must view any proposals for improvement favorably before being convinced to begin effective operation. Thus, even though Chilalo does not present a very attractive case for investment under benefit-cost analysis techniques, the anticipated increase in net returns from the farmer's viewpoint, at least at high production levels, appears to be quite substantial. This observation suggests that the proposals may find enthusiastic support from local farmers.

Employment and Distribution of Income

The data compiled to show the extent of increase in labor unit requirements were computed from total labor requirements in each case.[1] Since constant wage rates are assumed in the budget models, the index of employment is also an index of total labor earnings in each case. However, the cash content of these earnings appears to increase substantially in Agnale and Chilalo as indicated by the data on annual cash earnings in Table 17. In contrast, since Setit-Humera and Tendaho are well established

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[1]To estimate relative sizes of annual labor employment between cases the index bases (t=0) are necessary, they are as follows: (1) Agnale, 44,328 man-hours; (2) Chilalo, 2,036 man-hours; (3) Setit-Humera, 62,256 man-days; (4) Tendaho, 60,056 man-days.

TABLE 17 Indices of annual employment and total labor earnings at three points in budget period (t=1,5,10), and cash percentage included in total labor earnings by case, Ethiopia

Case	Strategy	Production level	Annual employment at indicated year: Index[a] 1	5	10	Workers 0	1	5	10	Annual total labor earnings at indicated year: Index 1	5	10	Percentage of total earnings 0	1	5	10
			t_o=100			numbers				t_o=100						
Agnale	-	H	115.3	81.0	77.5	48	49	51	53	100.0[b]	3,025.8	62,429.1	-	1.1	38.9	65.5
		L	115.3	77.7	78.2	48	49	51	53	100.0	2,563.9	42,944.7	-	1.1	34.2	49.4
Chilalo	I--oxen	H	143.9	238.2	286.3	2.25[c]	2.92	2.92	2.92	85.1	309.4	423.8	42.0	24.9	54.6	62.2
		L	127.3	171.2	193.6	2.25[c]	2.92	2.92	2.92	45.7	150.2	203.5	42.0	15.1	36.9	44.2
	II--tractor hire	H	90.7	130.3	151.7	2.25[c]	2.42	2.42	2.42	87.2	181.4	232.2	42.0	40.4	58.5	64.4
		L	83.9	109.6	116.9	2.25[c]	2.42	2.42	2.42	71.2	132.2	149.6	42.0	35.6	50.7	53.8
Setit-Humera	I--labor intensive	H	128.5	135.5	140.4	90[d]	116	122	126	126.3	134.8	139.6	82.1	83.6	83.6	83.6
		L	126.5	133.2	135.8	90[d]	114	120	122	126.0	132.5	135.0	82.1	83.6	83.6	83.6
	II--machine intensive	H	90.0	109.4	111.5	90[d]	87	91	101	94.9	108.3	110.3	82.1	83.6	83.6	83.6
		L	95.8	107.5	107.5	90[d]	87	91	91	94.7	106.4	106.3	82.1	83.6	83.6	83.6
Tendaho	I--raw cotton	H	218.2	577.4	1,482.3	1,281[d]	2,795	7,400	18,997	218.2	577.4	1,482.3	100.0	100.0	100.0	100.0
		L	205.8	433.3	909.1	1,281[d]	2,636	5,553	11,651	205.8	433.3	909.1	100.0	100.0	100.0	100.0
	II--ginned cotton	H	228.5	630.6	1,660.5	1,281[d]	2,927	8,082	21,281	228.5	631.6	1,661.5	100.0	100.0	100.0	100.0
		L	214.3	465.5	1,004.1	1,281[d]	2,745	5,966	12,869	214.3	465.5	1,004.1	100.0	100.0	100.0	100.0

[a]Index of total employment and index of total labor earnings are same because constant wage rate is assumed.

[b]Cash earnings for Agnale in t=0 are zero, therefore index base is at t=1.

[c]Initiating year labor force consists of: farmer=1 labor unit, resident laborer=1 labor unit, farmer's wife=.25 labor unit. Subsequent labor requirements met by hiring part-time labor.

[d]Large number of hired laborers; estimate based on requirements during harvest which is peak labor requirement.

cash economies, the cash content of workers' earnings shows little change over the budget period.[1]

These data indicate a falling trend in annual employment for Agnale; rising trends for the other three cases. The increase in Chilalo approaches two to three times in strategy I (oxen) and 16-52 per cent in strategy II (tractor hire) the labor input in the initiating year supplied by increasing the employment of part time workers at peak seasons of the year. In Setit-Humera annual employment and the number of workers increase by about 35-40 per cent in strategy I (labor intensive) and 7-12 per cent in strategy II (machine intensive). In Tendaho, since the area under cultivation increases substantially, the increase in annual employment in the final budget year ranges from 9-14 times in strategy I, 10-16 times in strategy II the employment level of the initiating year.

The falling trend in employment in Agnale is largely due to two technological changes: the substantial improvements in labor productivity effected by the introduction of improved tools and improved storage which reduces the input of labor requirements for subsistence food although cash wages increase in total. These data illustrate an important aspect of planning strategy. If local

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[1]To estimate the relative size of annual labor cash earnings in each case the index bases (t=0) are necessary, they are as follows: (1) Agnale, $28; (2) Chilalo $43; (3) Setit-Humera, $31,728; (4) Tendaho, $36,761.

labor is to lend enthusiastic support to programs of improvement, it may be unwise to permit total returns to labor to fall because labor productivity is substantially improved by maintaining constant wages. Hence, wage increases should be included in such plans in order to compensate for reductions in labor requirements.

The overall impression given by the data in Table 17 is that the Tendaho Plantations case can provide very substantial employment opportunities for local economic development and generate substantial cash wage earnings each year. The case of Setit-Humera is less pretentious but nevertheless effective as an employment generator since this case can be multiplied many times: it is one case in an area which may contain many large farms of this nature. Chilalo data show increased labor requirements which will have to be met by attracting new labor into the area and also by increased man-hours from existing labor. The employment level in Agnale is a reflection of increases in the local populations; no influx of wage earners into the area is envisioned.

Field labor from the farming community of the surrounding highlands is employed on Tendaho Plantations. So long as the labor demands keep within the bounds of local supply, which necessitates a peak level of demand occurring when local farm labor demands are low, constant or slightly rising wage rate may be anticipated. In the Setit-Humera region, migrant workers arrive in large numbers for cultivation and harvest employment. These workers have shown a propensity to organize themselves into working groups which are in a strong bargaining position. Moderate wage increases are likely to occur in this area. In Chilalo Awraja, labor is relatively scarce although working for wages is a well-established practice. Moderate increases in the wage level can be anticipated as competition for labor increases and new labor may possibly be attracted into the area.

Relative intensities of labor utilization to land and invested capital are shown by the data in Table 18. In the initiating year[1] labor utilization per unit of land is least intensive becoming rapidly more labor intensive as oxen technology (strategy I) is improved. In Agnale, labor intensity, already high, increases substantially over the

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[1]Distribution of land in each case at years 0,1,5 and 10 is as follows:

Year	Agnale	Chilalo	Setit-Humera	Tendaho
	------------------hectares------------------			
0	73.97	5.1	800	1,100
1	66.35	5.1	800	2,165
5	54.42	(I)[a]6.6 (II)[b]7.1	800	5,030
10	(H)[c]30.32 (L)[d]46.06	(I) 6.6 (II) 7.1	802	10,000

[a]I--strategy I.

[b]II--strategy II.

[c]H--high level yields.

[d]L--low level yields.

TABLE 18 Annual labor utilization per unit of land and per unit of accumulated capital in operation at four points in budget period (t=0,1,5,10) by case, Ethiopia

Case	Strategy	Production level	Annual labor utilization per hectare at indicated year				Annual labor utilization per dollar of accumulated capital in operation			
			0	1	5	10	0	1	5	10
			---man-hours per hectare----				----man-hours per dollar----			
Agnale	-	H	599.2	770.3	614.6	1,133.0	161.8	16.8	5.1	4.5
		L	599.2	770.3	588.0	752.1	161.8	16.8	4.9	4.6
Chilalo	I--oxen	H	399.2	574.3	734.7	883.2	18.8	4.9	7.9	9.3
		L	399.2	508.2	528.2	597.3	18.8	4.4	5.7	6.2
	II--tractor hire	H	399.2	362.2	372.7	434.9	18.8	2.3	2.9	2.9
		L	399.2	335.1	314.4	335.2	18.8	2.1	2.5	2.3
Setit-Humera	I--labor intensive	H	622.6	799.6	843.3	871.7	22.7	28.9	30.4	31.4
		L	622.6	787.4	828.8	642.7	22.7	28.5	29.9	30.4
	II--machine intensive	H	622.6	597.3	681.1	692.3	22.7	12.7	14.1	13.4
		L	622.6	595.8	669.2	667.0	22.7	12.7	13.9	13.9
Tendaho	I--raw cotton	H	436.8	483.9	551.6	712.2	0.6	1.0	1.0	1.5
		L	436.8	456.4	413.8	436.8	0.6	0.9	0.7	0.9
	II--ginned cotton	H	436.8	506.8	602.3	797.8	0.6	0.9	1.0	1.6
		L	436.8	478.2	444.7	482.4	0.6	0.8	0.7	1.0

budget period as does the intensity of capital employed relative to labor. From these data Agnale is clearly indicated to be the most labor intensive case; labor utilization per dollar of capital is relatively very low in the case of Tendaho.

Productivity of Factors

Gross output per unit of productive factor is a crude estimate of factor productivity. There is no way of refining this form of estimate without more precise data about the nature of the production function. Furthermore, while indications of increasing productivity may be assumed from rising values for gross output per unit of productive factor,[1] nothing precise can be determined about the

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[1]The number of units of productive factors are the units of land, labor, and capital employed in each year. Units of capital (dollars of investment) raise the problem of how to treat investments occurring in previous years and continuing in use during the year in question. One alternative is to depreciate the capital and accumulate depreciated capital to the particular year. This method has the disadvantage of a tendency to underestimate the capital value in terms of alternative resources foregone in order to invest: in any given year a piece of equipment purchased in the past (providing the purchase date is relatively recent and not in antiquity) represents the cost of acquisition to the operator rather than its depreciated value (which is really a reflection of its salvage value.) A second alternative is to depreciate the investment over the period of medium-term loans. This method has the disadvantage of tending to overestimate the capital value by overlapping in the accumulation: some equipment depreciates more rapidly than others but treating all investments in the same way results in the introduction of some replacements before the original item is fully depreciated; the accumulation to a given year then includes some double counting. A third alternative, the one used, is to

relative level of returns to each factor and, hence, the distribution of the total product. However, the data in Table 19 indicate that gross output per unit of each factor increases after initial investments have taken place, for each productive factor. This suggests that, while nothing can be deduced about the relative distribution of the total product, there is evidence that the production function in each system is rising and, hence, returns to productive factors can be expected to increase over the budget period.

Potentials for Export and Import Substitution

The potential for the agricultural systems either to earn foreign exchange or substitute for imports, and thereby save foreign exchange, was estimated both on the basis of potential to earn or save foreign exchange and the expression of this potential per unit of invested and operating capital. The second expression was determined

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accumulate the original acquisition price of capital over the lifetime of each piece of equipment and to eliminate it at the end of the depreciation period. Thus gross output is expressed as a fraction of accumulated capital in operation. Accumulated capital in operation in each case at years 0,1,5, and 10 is as follows:

Year	Agnale	Chilalo		Setit-Humera		Tendaho	
	---------U.S. dollars---------						
0	274	112		21,898		843,384	
	Strategy	I	II	I	II	I	II
1	3,041	593	803	22,123	37,572	1,014,483	1,284,161
5	6,994	616	902	22,206	38,515	2,835,212	3,105,890
10	7,556	630	1,050	22,298	38,607	4,784,017	5,054,695

TABLE 19 Estimated annual gross output per unit of labor, land, and accumulated operating capital at four points in budget period (t=0,1,5,10) by case, Ethiopia

Case	Strategy	Production level	Annual gross output per man-hour at indicated year				Annual gross output per hectare at indicated year				Annual gross output per dollar of accumulated operating capital at indicated year			
			0	1	5	10	0	1	5	10	0	1	5	10
			dollars[a]											
Agnale	-	H	0.10	0.12	0.34	0.75	61.62	69.42	210.97	843.29	16.41[b]	1.51[c]	1.76	3.38
	-	L	0.10	0.12	0.24	0.49	61.62	69.42	140.51	366.33	16.41[b]	1.51[c]	1.17	2.23
Chilalo	I--oxen	H	0.16	0.18	0.26	0.28	64.77	105.17	192.50	247.64	2.93[d]	0.90	2.06	2.59
		L	0.16	0.15	0.21	0.22	64.77	78.58	108.72	134.62	2.93[d]	0.68	1.16	1.41
	II--tractor hire	H	0.16	0.31	0.56	0.60	64.77	112.92	207.63	262.94	2.93[d]	0.72	1.63	1.78
		L	0.16	0.24	0.36	0.42	64.77	81.46	113.67	140.24	2.93[d]	0.52	0.89	0.95
Setit-Humera	I--labor intensive	H	0.14	0.13	0.16	0.20	86.50	103.46	135.30	172.32	3.78	3.74	4.87	6.20
		L	0.14	0.13	0.14	0.17	86.50	101.29	118.68	139.14	3.78	3.66	4.28	5.00
	II--machine intensive	H	0.14	0.17	0.20	0.25	86.50	103.53	137.54	174.71	3.78	2.20	2.86	3.63
		L	0.14	0.17	0.18	0.21	86.50	101.36	120.92	140.88	3.78	2.16	2.51	2.93
Tendaho	I--raw cotton	H	0.29	0.38	0.74	0.97	128.80	180.00	409.40	690.00	0.17	0.39	0.73	1.44
		L	0.29	0.33	0.60	0.84	128.80	151.80	248.40	368.00	0.17	0.32	0.44	0.77
	II--ginned cotton	H	0.29	0.48	0.92	1.17	128.80	241.58	553.79	933.35	0.17	0.41	0.90	1.85
		L	0.29	0.22	0.76	1.03	128.80	199.30	336.00	497.79	0.17	0.34	0.54	0.98

[a]Dollar values in these analyses are U.S. dollars.

[b]All investment in Agnale at t=0 is non-cash capital at imputed values.

[c]Taking entire system into account both non-cash and cash investments are included in capital values.

[d]Capital investment in t=0 is mainly non-cash and is replaced in t=1 by cash investment.

as a gross value and also as a value net of inputs which involve the spending of foreign currency, i.e., for imported capital equipment and fuel.[1]

Foreign exchange earning potential is estimated on the basis of assumptions for the quantity of any given change in production which will tend to be exported or substituted for imports. The data used are shown in Table 20.

In the case of Agnale and Chilalo, the present systems are established in production for subsistence needs with a small quantity of saleable crops; therefore, increases in production brought about by technological improvements are considered potentially for cash transaction. In the cases of Setit-Humera and Tendaho, it can be assumed that without the initial investments in relatively sophisticated technology there would be no production; therefore, all production is considered potentially

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[1]Ethiopia imported 214.8 thousand tons of petroleum fuel products and 25,161.1 tons of crude oil for refining. (See Imperial Ethiopian Government, Statistical Abstract 1967 and 1968, op. cit., p. 98.) Value added to crude oil imports during the process of refining into fuel has been estimated at approximately 30 per cent of the value of imported material. (See U.S., Department of Commerce, Bureau of the Census, 1967 Census of Manufactures (Washington, D.C.: Government Printing Office, October, 1970), Pt. 29A, p. 6.) Assuming approximately 5 per cent value added for imported petroleum fuels during the course of distribution then, it is estimated that 87-88 per cent of the fuel bill on any farming operation represents expenditure of foreign exchange.

TABLE 20 Estimated percentages of production increases absorbed in domestic and export markets, Ethiopia

Crop	Percentages of production increases absorbed in market indicated		
	Domestic market		Export market
	Demand increase	Import substitution	
	per cent		
Barley	100	-	-
Maize[a]	85	-	15
Sorghum[a]	85	-	15
Teff	100	-	-
Wheat	50	50	-
Peas	75	-	25
Beans[a]	50	-	50
Flax	-	50	50
Linseed	25	-	75
Sesame	15	-	85
Cotton	25	75	-
Citrus	10	15	75

[a]Agnale production is purely for subsistence.

Source: Carl F. Miller, James D. Sarton, James L. Mackin, and Peter O. Strom, Systems Analysis Methods for Ethiopian Agriculture, Final Report, SRI Project 6350-202, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, April, 1968), p. 117.

for cash transaction. The distribution of these transactions between export, import substitution, and increase in domestic demand is shown in Table 21.

Indices on the base of production in the first year of the budgets computed to indicate the rate at which foreign exchange potential (export or import substitution) can be expected to increase are shown in Table 21. In the case of Agnale, this increase is extremely great although

TABLE 21 Annual foreign exchange earning potential indices, annual gross and net foreign exchange earning potential per dollar accumulated operating capital at three points in budget period (t=1,5,10) by case, Ethiopia

Case	Strategy	Production level	Index of annual foreign exchange earning potential at indicated year: Base (t_1=100)	1	5	10	Annual gross foreign exchange earning potential per dollar of accumulated capital in operation at indicated year: 1	5	10	Annual net foreign exchange earning potential per dollar of accumulated capital in operation at indicated year: 1	5	10
			dollars[a]				---	---	---	dollars[a] ---	---	---
Agnale	-	H	60.36[b]	100.0	11,354.6	30,671.5	0.02	1.01	2.51	-0.01	0.98	2.48
		L	60.36[b]	100.0	5,185.3	17,780.0	0.02	0.46	1.45	-0.01	0.44	1.43
Chilalo	I--oxen	H	87.61[b]	100.0	467.6	634.4	0.15	0.66	0.88	0.14	0.63	0.86
		L	87.61[b]	44.0	205.0	292.7	0.06	0.29	0.46	0.05	0.27	0.39
	II--tractor	H	136.37[b]	100.0	393.8	511.7	0.17	0.60	0.66	0.01	0.49	0.58
	hire	L	136.37	50.7	181.8	243.7	0.09	0.27	0.32	-0.07	0.12	0.28
Setit-Humera	I--labor	H	57,541[b]	100.0	138.5	177.4	2.60	3.59	4.58	2.22	3.18	4.13
	intensive	L	57,541[b]	98.9	121.4	143.4	2.55	3.14	3.70	2.17	2.74	3.26
	II--machine	H	57,911[b]	100.0	143.1	180.9	1.54	2.15	2.71	1.11	1.76	2.29
	intensive	L	57,911[b]	97.8	125.9	146.4	1.51	1.89	2.20	1.07	1.50	1.77
Tendaho	I--raw	H	298,770[b]	100.0	516.9	1,732.1	0.30	0.54	1.08	0.18	0.47	0.93
	cotton	L	298,770[b]	82.5	378.1	923.8	0.24	0.40	0.58	0.13	0.32	0.43
	II--ginned	H	392,261[b]	100.0	532.6	1,784.6	0.31	0.67	1.38	0.08	0.60	1.24
	cotton	L	392,261[b]	82.5	323.1	951.8	0.25	0.41	0.74	0.03	0.34	0.60

[a]Dollar values for these analyses are all U.S. dollars.

[b]Base for annual foreign exchange net of imported inputs are as follows: Agnale, -42.60; Chilalo,--strategy I, 79.61, --strategy II, 2.37; Setit-Humera,--strategy I, 49,222,--strategy II, 41,608; Tendaho,--strategy I, 186,902,--strategy II, 106,247.

the relative size of the project is quite small (shown by the index base). The reason for this rapid increase is found in the excellent export potential for citrus crops and the fact that Agnale is operating on a very small base in the early years of the budget. The indices for Tendaho also increase rapidly. The size of this operation increases substantially over the budget period contributing, thereby, a substantial increase in production. The relative size of the operation appears to be very large as indicated by the index bases. Chilalo indices increase more rapidly than those of Setit-Humera. A probable explanation is the extremely small foreign exchange potential in the early years in contrast to Setit-Humera where substantial export crops are produced from the initiating year.

Expressing these foreign exchange potentials per unit of capital in operation, at a given time, gives a similar measure to a benefit-cost criterion of NPV/K for foreign exchange except that in the benefit-cost analysis technique this fraction affords a single number for comparison where individual yearly calculations afford an indication of trends over time. Having common denominators, these values permit comparison. Agnale and Setit-Humera cases stand out clearly as having the highest foreign exchange potential. Modifications to these values when the foreign exchange expenses are taken into account do not change the order of the potentials. The reduction in potentials is most marked in those systems in which capital commitments to machinery are heaviest, i.e., Setit-Humera and Tendaho.

Sensitivity Analyses

The detailed results of the sensitivity analyses are contained in Appendix G. The data given in Table 22 present a selection of these analyses in terms of relative changes in benefit-cost criteria due to relative changes in the selected parameter. Thus, from these data elasticities of changes can be determined although, with a constant rate of change for each parameter, the rates of each set of changes in the benefit-cost criteria are already based on a common denominator. Except in the case of changes in discount rates, the relationships of these changes are linear. Hence, given one set of changes other levels of relative change may be determined on a proportional basis. Only data for the high production levels are analyzed; in the cases of Agnale and Chilalo the analyses are only applied to run 2 data.

Change in Total Product

Data in Table 22 give relative changes in benefit-cost criteria for a 40 per cent increase in total product. Such an increase can occur as a result of some conbination of increased crop yields and rising market prices for products.

TABLE 22 Relative changes in financial performance criteria due to given changes in six selected parameters in benefit-cost analyses (high production level) by case, Ethiopia

Case	Strategy	$\frac{\Delta NPV}{NPV}$	$\frac{\Delta IRR}{IRR}$	$\frac{\Delta B/C}{B/C}$	$\frac{\Delta NPV/K}{NPV/K}$	$\frac{\Delta NPV/T_W}{NPV/T_W}$	$\frac{\Delta NPV/T_{WS}}{NPV/T_{WS}}$
		ratio					
1. Increase in total product: $\frac{\Delta \text{ Total product}}{\text{Total product}} = +0.40$[a]							
Agnale	-	+0.52	+0.24	+0.40	+0.52	+0.52	+0.52
Chilalo	I--oxen	+2.41	+1.49	+0.40	+2.42	+2.41	+2.42
	II--tractor hire	+6.77	+3.64	+0.41	+6.72	+6.71	+6.77
Setit-Humera	I--labor intensive	+2.61	›+6.84	+0.40	+2.61	+2.61	+2.61
	II--machine intensive	+1.80	›+5.92	+0.40	+1.80	+1.80	+1.80
Tendaho	I--raw cotton	+3.23	+1.18	+0.40	+3.22	+3.22	+3.24
	II--ginned cotton	+1.67	+0.84	+0.40	+1.68	+1.88	+1.67
2. Increase in labor input: $\frac{\Delta \text{ Labor}}{\text{Labor}} = +0.40$							
Agnale	-	-0.18	-0.31	-0.37	-0.17	-0.18	-0.18
Chilalo	I--oxen	-0.56	-0.40	-0.10	-0.57	-0.56	-0.56
	II--tractor hire	-0.81	-0.38	-0.05	-0.81	-0.82	-0.80
Setit-Humera	I--labor intensive	-0.73	-0.96	-0.19	-1.30	-1.27	-1.26
	II--machine intensive	-0.70	-0.63	-0.17	-0.70	-0.70	-0.70
Tendaho	I--raw cotton	-0.38	-0.18	-0.05	-0.39	-0.38	-0.38
	II--ginned cotton	-0.15	-0.09	-0.04	-0.15	-0.15	-0.15
3. Increase in discount rate: $\frac{\Delta i}{i} = +0.50$							
Agnale	-	-0.32	-	-0.14	-0.24	-0.16	-0.16
Chilalo	I--oxen	-0.34	-	-0.03	-0.28	-0.19	-0.19
	II--tractor hire	-0.67	-	-0.03	-0.64	-0.60	-0.60
Setit-Humera	I--labor intensive	-0.30	-	-0.03	-0.22	-[b]	-[b]
	II--machine intensive	-0.26	-	-0.04	-0.48	-[b]	-[b]
Tendaho	I--raw cotton	-0.66	-	-0.07	-0.61	-0.59	-0.58
	II--ginned cotton	-0.43	-	-0.07	-0.33	-0.28	-0.29
4. Increase in foreign exchange rate: $\frac{\Delta \text{ Exchange rate}}{\text{Exchange rate}} = +0.20$							
Agnale	-	-0.03	-0.01	-0.01	-0.02	-0.02	-0.02
Chilalo	I--oxen	-0.02	-0.01	-[b]	-0.02	-0.01	-0.01
	II--tractor hire	-0.51	-0.22	-0.03	-0.53	-0.44	-0.60
Setit-Humera	I--labor intensive	-0.16	-0.09	-0.01	-0.16	-0.12	-0.12
	II--machine intensive	-0.14	-0.09	-0.02	-0.15	-0.11	-0.11
Tendaho	I--raw cotton	-0.23	-0.09	-0.03	-0.24	-0.13	-0.14
	II--ginned cotton	-0.15	-0.07	-0.02	-0.15	-0.11	-0.12
5. Increasing trend in output: $\frac{\Delta \text{ Total product}}{\text{Total product}}$ p.a. = +.015[c]							
Agnale	-	+0.15	+0.06	+0.11	+0.15	+0.15	+0.15
Chilalo	I--oxen	+0.50	+0.20	+0.08	+0.50	+0.50	+0.50
	II--tractor hire	+1.40	+0.50	+0.08	+1.39	+1.38	+1.40
Setit-Humera	I--labor intensive	+0.46	+0.22	+0.07	+0.45	+0.47	+0.46
	II--machine intensive	+0.32	+0.13	+0.07	+0.31	+0.32	+0.32
Tendaho	I--raw cotton	+0.82	+0.24	+0.20	+0.90	+0.79	+0.85
	II--ginned cotton	+0.43	+0.18	+0.11	+0.43	+0.43	+0.43
6. Increasing trend in labor input: $\frac{\Delta \text{ Labor}}{\text{Labor}}$ p.a. = .015[c]							
Agnale	-	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]
Chilalo	I--oxen	-0.01	-[b]	-[b]	-0.01	-0.01	-0.01
	II--tractor hire	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Setit-Humera	I--labor intensive	-0.20	-0.12	-0.04	-0.19	-0.20	-0.20
	II--machine intensive	-0.11	-0.06	-0.03	-0.11	-0.11	-0.11
Tendaho	I--raw cotton	-0.09	-0.04	-0.01	-0.10	-0.10	-0.10
	II--ginned cotton	-0.03	-0.02	-0.01	-0.03	-0.03	-0.03

[a] A scale factor is incorporated into the program in order to increase or decrease selected inputs and outputs by a given amount. The scale factor for a 40 per cent increase is 1.40.

[b] Computations have been rounded to two decimal places; these values are less than .005, therefore round to 0.

[c] A price function (P = A + B(t)) is also incorporated into the program in order to introduce trends in the price of selected inputs and outputs. If A = 1.0, then a trend of +1.5% per annum is effected when B = +.015.

The effect on Agnale criteria is to increase NPV and related criteria (modified benefit-cost ratios: NPV/K, NPV/T_W, NPV/T_{WS}) by about 50 per cent, IRR by 24 per cent, and B/C by 39 per cent. These changes are substantial when viewed in absolute values (NPV increases by $18,165)[1] but cash crop values from the system are relatively high, therefore relative changes to a 40 per cent increase in total product do not tend to be large.

Chilalo data present a contrasting case in which the increase in NPV for strategy I (oxen) is 2.41 times greater than the original NPV and for strategy II (tractor hire) is 6.77 times greater. Increases in IRRs and B/Cs are smaller but nevertheless substantial. The costs of inputs are much smaller in strategy I (oxen) than in strategy II with a consequent higher NPV for strategy I than for strategy II. Hence, relative increases in NPVs for a 40 per cent increase in total product show a greater increase in the NPV for strategy II. These results suggest that yield achievements and/or market price for products are extremely important to the success of introducing improved mechanized agricultural technology into a small-scale farming system, especially when engine-powered technology is involved. IRR increases are also large.

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[1]Absolute values can be obtained from data tabulated in Appendix G; e.g., $53,005 - $34,840 = $18,165.

The results for Setit-Humera suggest that net gains result from increases in total product although relative to the original NPVs, which are high, the relative increases are less than in either Chilalo (strategy II: tractor hire) or Tendaho. IRR increases are also large.

The data for Tendaho also suggest that substantial net gains result from increases in total product, especially in strategy I (raw cotton) in which the value of the product is considerably smaller than that of strategy II (ginned cotton). Hence, the relative increase in net gains is much greater due to a 40 per cent increase in total product in strategy I over strategy II.

Change in Labor Input

Benefit-cost criteria are negatively correlated to changes in labor input. The data in Table 22 indicate highest relative changes to a 40 per cent increase in labor inputs are observed for Chilalo (strategy II: tractor hire) and Agnale. Sensitivity to change in labor inputs tends to be high in systems in which net gains are small and in which the labor content of the input-mix is high. Hence, changes tend to be relatively large. The fact that considerable quantities of labor are employed in Setit-Humera is demonstrated in the relatively high values for changes in NPVs and modified B/Cs. In Tendaho these relative changes are somewhat less and the changes in modified B/Cs are smaller. In Setit-Humera strategy II (machine intensive) much less labor is employed than in strategy I although the nature of total products is similar. Hence, the change in labor inputs in strategy II has much less relative effect than in strategy I. In Tendaho the quality of the total products is different; in the two strategies, that of strategy II (ginned cotton) has considerably more value than that of strategy I (raw cotton). Hence, although more labor is employed in strategy II, the relative effect of a 40 per cent change in labor input is less marked in strategy II than in strategy I.

Change in Discount Rate

Relationships between benefit-cost criteria and discount rates are curvilinear.[1] The correlation between the criteria and the discount rate is negative.

From the data of the analyses, it appears that benefits are reduced most rapidly in Agnale when the discount rate is increased by 50 per cent (from .10 to .15). The cost of inputs over the budget period, in the Agnale case are relatively small and increase only moderately in contrast to the output which increases substantially in the early years and continues to expand beyond the budget period. Increasing the discount rate tends to have greatest effect on those projects in which initial input costs

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[1]See Figure 3.

are relatively high and yield increases delayed to some time after initial investments.

Increasing the discount rate above that selected on the basis of the opportunity cost of capital has legitimacy in a sensitivity analysis. It can be argued that, in fact, the social returns to capital investments are greater than the opportunity cost of capital (assumed in these analyses to be 10 per cent per annum) since prudent investment over the long run will foster secondary and tertiary benefits of development neglected in the opportunity cost concept. Such benefits as linkage and economic integration, engendered by the most desirable investment projects, defy quantification and tend to be neglected in the selection of appropriate discount rates.

Change in the Rate of Foreign Exchange

In each case different quantities of imported capital equipment are incorporated into the productive system during improvement and mechanization processes.[1] The data in Table 22 show the effect of a 20 per cent

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[1]Foreign exchange requirements for imported capital will consist of the portion of capital equipment which is actually paid for during the period under consideration. Estimates of imported capital paid for during the budget period expressed as percentages of the value of total capital in operation are as follows: Agnale, 10.93 per cent; Chilalo--strategy I, 5.12 per cent,--strategy II, 67.85 per cent; Setit-Humera--strategy I, 59.35 per cent,--strategy II, 52.97 per cent; Tendaho,--strategy I, 39.62 per cent,--strategy II, 40.77 per cent.

increase in the current cost of imported capital equipment. The effect is small in cases employing relatively little imported equipment, i.e., Agnale and Chilalo, strategy I (oxen). There is an increased effect in those cases for which output is high in relation to the quantity of imported capital, i.e., Setit-Humera and Tendaho, strategy I. The greatest effect is observed where output is relatively low in relation to imported equipment, i.e., Chilalo, strategy II (tractor hire) and Tendaho, strategy I (raw cotton).

Foreign exchange rate is an important consideration since an over valuation of domestic currency undervalues the cost of imported capital equipment in terms of alternative uses for resources devoted to the purchase of imported equipment. Evidence for the over or under valuation of Ethiopian currency is virtually unavailable.[1] Hence, this sensitivity analysis merely suggests the possible effect of over valuation.

Trend Effect in Total Product

An overall increase in total product of 40 per cent is useful to determine the effect of having originally underestimated output by this amount. To investigate the

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[1]Black market trade in United States currency suggests an exchange rate of E$2.60 = U.S.$1.00 instead of the fixed rate. This figure gives an over valuation of 8.3 per cent for Ethiopian currency at the fixed exchange rate.

effect of a general rise in product prices and/or yields, it is more usual to assume a percentage increase each year. The data presented in Table 22 demonstrate the effect of an annual increase in total product of 1.5 per cent of the level assumed in the initiating year. The data show relatively similar effects on the results of an overall increase in total product of 40 per cent although less dramatic because of the lower percentage increase. Net gains accrue most rapidly to those cases in which the original NPV is low relative to capital investments, i.e., Chilalo, strategy II (tractor hire) and Tendaho, strategy I (raw cotton). The trend effect tends to emphasize B/Cs in those cases in which a substantial annual increase in output occurs: Agnale where citrus yields increase substantially over the budget period and beyond, and Tendaho where the area under cultivation is increased almost 10 times over the budget period with gradually improving yields.

Trend Effect in Labor Input

The trend effect of a 1.5 per cent annual increase in wages is observed to be most marked in those cases employing high quantities of manual labor relative to the product value, i.e., Setit-Humera and Tendaho, strategy I (raw cotton). In the case of Setit-Humera, changes are relatively high which suggest that moderate annual increases in the wage level are likely to have a marked effect on entrepreneurs' expected net gains.

Through the sensitivity analyses the relative effect of single changes can be observed. Highest relative changes occur with increasing total output values. The most pronounced effect is observed in Chilalo, strategy II (tractor hire) where the value of the total product to investment cost is relatively low. Increased labor costs are observed to have the greatest effect in cases of low output relative to the quantity of labor employed.

Two aspects of the systems are neglected in this form of analysis. Firstly, the fact that within the system isolated changes in parameters usually cause other adjustments; secondly, within the system several parameter changes may occur simultaneously. Thus, the sensitivity analyses tend to be a measure of gross effect and not the net effect of given changes. Net effects of single changes or a set of changes can be ascertained by generating new data in the budget models so far as these cases are representative of the real world situation.

Effect of Price Changes on the Analyses

The budget models were each computed in the first instance using constant prices (those observed in the initiating year). Such assumptions are sufficient to permit the comparison of different agricultural systems from the standpoint of technological conditions of production. However, when decisions are to be made concerning the relative returns to investment proposals, it is important to take into account the influence that market conditions are likely to have on effective demand over the planning horizon of the proposal.

The selection of the various products of each system was made in the light of anticipated future demand. However, as already discussed above, the level of demand for a given product is affected by both the domestic and international levels of demand, depending on the relative quantities of domestic product exported or the extent to which domestically produced commodities must compete with imports.

Within the context of economic development a large number of combinations of price changes may be envisioned for outputs and inputs. The most important questions regarding price changes faced by decision-makers, whether farmers or government planners, generally appear to be with regard to shifts in market prices for cash crop and shifts in wage levels. Therefore, the budget models were recomputed using assumed price trends in place of constant prices for marketed products and for wages.

Anticipated Trends in Crop Prices

Data on total crop production and demand projections are unavailable in sufficient detail to predict future prices with accuracy. The Food and Agriculture Organization's projections[1] and Eichberger's estimates of domestic food crop production and utilization[2] were used as the best available information on which to approximate possible shifts in supply and demand. World price trends for imports and exports used in these second computations are approximations from data published by the United Nations.[3] Price trends are shown in Table 23 and the evidence for these assumptions is discussed below.

Wheat is a cash crop only in the Chilalo case study. The annual decrease in wheat price of 0.73 per cent was assumed as a rough approximation based on: modestly declining world wheat prices (around 0.5 per cent per annum over the period 1960-66); assumed local prices for 1968 of

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[1]United Nations, Agricultural Commodities: Projections for 1975 and 1985 (Rome: Food and Agriculture Organization, 1965), pp. 88-99.

[2]Wheat production is required to increase by 3.6 per cent annually to maintain self-sufficiency, when average annual food crop increases are around 2.7 per cent. Eichberger, "Food Production and Utilization . . . ," p. 43.

[3]United Nations, Trade Year Book (Rome: Food and Agriculture Organization), Vol. XX (1966), Vol. XXI (1967), passim.

TABLE 23 Crop and labor initiating prices and price trends for budget computations (t=0,...,10) using non-constant prices by case, Ethiopia

Agnale			Chilalo			Setit-Humera			Tendaho		
Item	Initiating price (A)[a]	Trend (B)[b]	Item	Initiating price (A)	Trend (B)	Item	Initiating price (A)	Trend (B)	Item	Initiating price (A)	Trend (B)
	\$/q.[c]			\$/q.[c]			\$/q.[c]			\$/q.[c]	
Maize	4.00	-	Wheat	8.72	-.0073	Sesame	20.15	+.0019	Cotton	23.00	+.0095
Sorghum	4.00	-	Barley	6.32	+.0014	Cotton	25.00	-.0096	Lint	70.00	+.0095
Beans	6.40	-	Maize	5.52	+.0018	Sorghum	4.84	+.0057	Seed	8.06	+.0095
Sesame	16.26	+.0024	Teff	10.48	-	Beans	9.60	+.0020			
Citrus	8.26	+.0031	Flax	9.92	+.0102						
			Peas	7.92	-						
			Beans	6.00	+.0159						
	\$/hr.[c]			\$/hr.[c]			\$/hr.[c]			\$/hr.[c]	
Labor	0.06	+.0290	Labor	0.05	+.0150	Labor			Labor		
						planting	0.80	+.0200	picking	0.90	+.0150
						other	0.60	+.0200	other	0.60	+.0150

[a]Price observations during initiating year (=1968) assumed constant in initial budget computations by employing the price equation: P = A(1+B(t)), where B=0 and t=0 (the initiating year) and t=1,...,10 (the operational years of the budget).

[b]Coefficient (B) for the price equation: P = A(1+B(t)), for second budget computations using non-constant prices.

[c]Dollar values for these analyses are all U.S. dollars.

approximately 21 per cent higher than world import prices; the policy objective to remain self-sufficient in food production; and a possible wheat deficit increasing by 1.9 per cent per annum.

Barley is a cash crop only in the Chilalo case. The annual increase of 0.14 per cent was assumed as a cautious approximation based on: substantially declining world prices (around 5 per cent per annum); assumed local prices for 1968 of approximately 13 per cent below world import prices; and a maximum annual importation of 5 per cent of total requirements, since barley requirements are not expanding as rapidly as those for wheat.

Maize is a cash crop in the Chilalo case with good potential for export into the world market. In Agnale, maize is grown for subsistence only and, therefore, in this case the price was assumed to be constant. The annual increase of 0.18 per cent in maize prices for Chilalo is based on: indications of increasing world price for maize exports (approximately 3 per cent per annum); and the possibility of exporting maize up to a maximum of 15 per cent of total national production. The local price for 1968 was assumed to be approximately that of the world export price.

Flax is grown only in the Chilalo case. Demand is anticipated to increase in the domestic market which domestic production is likely to meet with a surplus production of up to 15 per cent available for export. The annual increase of 1.02 per cent was assumed based on: the assumed local price for 1968, approximately 15 per cent below world export prices; world export prices declining at an approximate annual rate of 2 per cent.

Beans appear to have a promising future as an export crop. An annual rate of increase of 0.2 per cent was assumed for Setit-Humera and 1.59 per cent for Chilalo based on: the assumed Chilalo price for 1968 being 50 per cent below the world export price (declining at about 1.3 per cent per annum); the Setit-Humera price for 1968 being 25 per cent below world export prices for 1968; declining world export prices being likely to have a more marked impact on Setit-Humera production than on Chilalo because of the commercial nature of production in Setit-Humera.

Sesame provides another promising export crop for which prices have been increasing substantially (at approximately 2.1 per cent per annum). Some overproduction is anticipated in which case modest price declines may occur. In Setit-Humera a small increase of 0.19 per cent per annum was assumed based on the Setit-Humera price for 1968 being the same as the world export price. In Agnale a larger increase of 0.24 per cent was assumed based on the Agnale price being 20 per cent below the current export price.

Future cotton production in Ethiopia will be essentially for import substitution. A small decreasing trend of 0.096 per cent per annum was assumed in the case of Setit-Humera and a similar annual increase in the

Tendaho case based on: imported lint prices declining by about 0.8 per cent annually; assumed 1968 prices for Setit-Humera being above the trend of prices; assumed 1968 prices for Tendaho cotton being below the trends. Moreover, Tendaho cotton is of superior quality and may become an important export.

Sorghum export prices were assumed to be increasing according to the general impression of rising world prices for coarse grains. In the case of Setit-Humera, sorghum is an important export crop for which local prices have slumped rapidly due to overproduction. In view of the export potential of the crop, however, a modest increasing annual trend of 0.57 per cent was assumed for Setit-Humera. In the Agnale case, however, sorghum is a subsistence crop and, therefore, a constant price was assumed.

Citrus world export prices are expected to decline slightly in order to clear small surpluses in production. However, the assumed prices for 1968 were some 25 per cent below world export prices, so that a small increase in price of 0.31 per cent per annum was assumed for Agnale.

Assumed labor prices were increased for each case. The assumed increasing trends of 1.5 per cent per annum in Chilalo and Tendaho cases were based on the assumption that the substantial increases in work requirements are likely to lead to small wage increases. This assumption is more readily substantiated in the case of Chilalo where there appears to be less temporary labor available than in the Tendaho case. In Setit-Humera, migrant workers are well organized into bargaining groups, consequently, wages may rise more rapidly than in the first two cases, thus, an annual increase of 2.0 per cent was assumed. In the case of Agnale, despite the increasing cash wage received by labor, the total value of returns to labor (valued at the constant wage rate of $0.06 per man-hour) declined substantially due to improved labor productivity. The annual rate of increase of 2.9 per cent for wages was assumed to compensate the worker for the total loss due to reduction in total hours of work required. By employing such a high rate of annual increase, cash wages will tend to rise quite rapidly.[1]

Changes in Benefit-cost Analyses Caused by Assumed Trends in Prices

The data contained in Table 24 show evaluated criteria of the benefit-cost analyses. Only NPV, PB, IRR, and B/C are tabulated since these criteria are sufficient

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[1]If cash wages are to be permitted to rise fairly quickly the economy must provide adequate and desirable consumer goods for disbursement of this new income. It may be argued that wages should not be permitted to increase rapidly but, rather, increasing surplus should be used to provide new tax revenues. An important economic consideration, beyond the scope of these analyses, is the extent to which increasing factor productivity can provide tax revenue and the extent to which taxation may act as a disincentive to the productive capabilities of the factors.

TABLE 24 Selected financial performance criteria from benefit-cost analyses of budget data (t=0,...,10) at high (H) and low (L) production levels by case using non-constant prices, Ethiopia

Case	Strategy (run)	Sum $PVTR_L$ ÷ Sum $PVTR_H$	Sum $PVTC_L$ ÷ Sum $PVTC_H$	Computed values for selected benefit-cost criteria							
				NPV		PB		IRR		B/C	
				H	L	H	L	H	L	H	L
				-------dollars[a]--------		----year----		---per cent--		dollar ratios	
Agnale	-	.536	.961	34,266	13,104	5	7	59.0	35.5	3.78	2.11
Chilalo	I--oxen	.562	.720	870	-361	5	>10	32.2	<0	1.16	0.91
	II--tractor hire	.545	.786	280	-1,519	9	>10	15.7	<0	1.04	0.72
Setit-Humera	I--labor intensive	.896	.977	90,449	30,132	4	7	45.4	25.5	1.14	1.05
	II--machine intensive	.894	.977	138,786	75,630	3	4	51.5	38.2	1.24	1.13
Tendaho	I--raw cotton	.538	.921	2,785,928	-3,520,177	8	>10	22.1	<0	1.21	0.71
	II--ginned cotton	.589	.880	5,521,406	-1,212,815	7	>10	30.6	2.9	1.36	0.91

[a]Dollar values for these analyses are all U.S. dollars.

to judge the extent to which shifts have occurred in financial returns to each budget model.

The changes in analytical results brought about by these changes in product and labor prices can be visualized most easily by examining the change which occurs in the order of rank. The new order of rank is shown in Table 25. There is no change in rank according to NPVs, PB (low-level), and IRR (high-level). Ranking according to PB (high-level), an exchange of 6th and 7th rank takes place between Chilalo (II) and Tendaho (I); ranking according to IRR (high-level) the changes are slight, and there are small reshuffles in the ranking according to B/C.

Within these categories of readjustment the following selective observations can be made:

1. Agnale. The small reduction in high-level NPV (1.6 per cent) is the result of moderate increase in cash crop prices being slightly more offset by increasing wages. These changes lead to a decline in IRR of 3.5 per cent and B/C of 12.1 per cent. The reduction in low-level NPV is much greater (7.4 per cent), increases in cash crop prices having been offset by both increasing wages and lower yields. The effect is to double the reduction of IRR (6.6 per cent). Anticipated net returns and rates of return remain high in this case, the

TABLE 25 Ranks according to selected benefit-cost criteria from analyses of budget data (t=0,...,10) at high (H) and low (L) production levels by case using non-constant prices, Ethiopia

Case	Strategy	Case rank according to value of criterion indicated							
		NPV		PB		IRR		B/C	
		H	L	H	L	H	L	H	L
		ranks							
Agnale	-	5	3	3}[a]	3	1	2	1	1
Chilalo	I--oxen	6	(4)[b]	3}	4}	4	(5)}	5	4}[c]
	II--tractor hire	7	(5)	7	4}	7	(5)}	7	6[c]
Setit-Humera	I--labor intensive	4	2	2	2	3	3	6	3
	II--machine intensive	3	1	1	1	2	1	3	2
Tendaho	I--raw cotton	2	(7)	6	4}	6	(5)}	4	7[c]
	II--ginned cotton	1	(6)	5	4}	5	4	2	4}[c]

[a]Bracket indicates equal ranking with one or more other cases.

[b]Parenthesis indicates negative value for ranking criterion.

[c]Ratio < 1.0

price changes serve to illustrate the importance of taking into account the way in which price changes, especially when coupled with changes in yield levels compensate or counteract each other.

2. Chilalo. Crop price changes are quite small, coupled with the annual wage increase of 1.5 per cent, heading to an overall decline of NPV in strategy I (oxen) of 18.0 per cent (high-level) and 43.2 per cent (low-level). The corresponding declines of NPV in strategy II (tractor hire) amount to 35.6 per cent (high-level) and 5 per cent (low-level). The relative size of decline is observed to be much larger in those strategies in which anticipated net returns (NPV) and rates of returns are already small, i.e., strategy II. Thus, these results suggest that where increasing input prices are likely to be substantially greater than a combination of output prices, in proposals for investment in projects which reveal low anticipated net returns, there is insufficient "cushion" in the financial returns to accommodate modest price changes. B/Cs are reduced to be very close to unity at high-level yields and are already less than unity at low levels.

3. Setit-Humera. Increasing labor costs are sufficient to more than offset increasing product prices in both strategies at both levels. In this system, however, there is sufficient "cushion" to accommodate the reductions in anticipated net returns without substantially reducing B/Cs, and IRRs are still very high. It is important to note that in strategy II (machine intensive) the relative decrease in NPVs is less than in strategy I (labor intensive) in contrast to the Chilalo case. Both strategies II are more highly mechanized (engine-power) than strategies I, but in Setit-Humera the higher degree of mechanization is accompanied by higher levels of returns.
4. Tendaho. High- and low-level yields move in opposite directions in strategy I (raw cotton) and in the same direction in strategy II (ginned cotton). These different movements can be explained by the fact that in strategy I increasing prices coupled with high yields for the low valued product (raw cotton) are sufficient to compensate for increase in wages and anticipated net returns increase; with low yields the compensation is inadequate and net returns increase in the negative direction.

In strategy II increases in the price for the high-valued product of cotton lint is sufficient to compensate for increases in wages at both high- and low-level yields.

Summary

Budget models employed to generate data for benefit-cost analyses were prepared in two different strategies for each of the Chilalo, Setit-Humera, and Tendaho cases. For Agnale only one form of hand-powered technology was deemed appropriate. For Chilalo, strategy I, the case under assumptions to improve the form of oxen-powered technology already established in the area is analyzed, strategy II, the case under assumptions to introduce a tractor hire service for tillage operations and harvesting cash crops is analyzed. For Setit-Humera engine-powered technology is employed in both strategies. In strategy I, the use of tractor power only in early tillage operations is assumed; in strategy II, more intensive use of tractor power in tillage, cultivation, and the harvesting of certain cash crops is assumed. Labor requirements in both strategies are provided by migrant workers. Tendaho, strategy I, the case for the production of raw cotton using engine-power for early tillage and cultivation operations, hand labor for weeding and picking is analyzed; in strategy II the same basic production techniques are employed with the additional ginning process to produce cotton lint and seed. Labor requirements are met from the many small farms in the surrounding highlands.

Benefit-cost analyses of Agnale data indicate very high rates of return (IRR), for both high and low production levels, and high anticipated average net returns for the selected scarce resources of capital, costs of professionals' salaries, and costs of professionals' wages and salaries (K, T_W, and T_{WS}). The implications of these analyses are that high potentials for increasing anticipated net returns (NPV) exist by introducing unsophisticated improvements into hand-powered systems, provided adequate supervision is available along with cooperation from the people in introducing new cash crops into the system.

Benefit-cost analyses of two strategies contained in Chilalo data indicate the anticipation of modest net returns (NPV) for high production levels and negative returns for low levels. The analyses suggest that in this system, where farms are small and fragmented with much effort devoted to producing for subsistence, that; firstly, high yields must be attained through relatively efficient management in order to avoid negative returns; secondly, improving established animal-powered technology leads to higher returns than introducing tractor hire services. This second conclusion appears to be derived from the fact that the tractor hire service requires much higher government investment than improving animal-powered technology and the necessity to concentrate unit extension facilities on fewer farmers.

Benefit-cost analyses of two strategies contained in Setit-Humera data indicate high rates of return (IRR) for both assumed production levels, and high average net returns for selected scarce resources (K, T_W, and T_{WS}). The implications are that, due to the large-scale operations in this system and the fact that individual private entrepreneurs are able to manage engine-powered technology for early tillage, investment in extension facilities can be spread over an extremely large area of productive land. Also, returns to strategy I tend to be lower than those to strategy II due to additional economies facilitated by the higher level of mechanization, but achieved at the expense of a lower level of employment.

Benefit-cost analyses of Tendaho data indicate high anticipated net returns (NPV) and moderately high rates of return (IRR) for high production levels but negative returns for low levels. These analyses suggest that the extremely heavy investment commitments implied in this system should be undertaken with caution if there is uncertainty about yield attainments. Average net returns for selected scarce resources tend to be lower than in Setit-Humera; investment in administrative facilities and costs of supporting technically trained professionals are very high in the Tendaho system. In this case, returns to strategy II (ginned cotton) are also higher than those to strategy I (raw cotton) but, since additional operations of the ginning process are incorporated, more labor is employed in strategy II.

In estimating the income generating capacities in each case, Agnale data demonstrate the most dramatic increases both in gross and net incomes, and the cash contents. In this case the computations of the system were initiated at a low productivity level on a completely non-cash basis, thus demonstrating these dramatic increases due to technological improvements. Important implications of these analyses lie in the fact that a substantial proportion of Ethiopia's population makes its livelihood in unsophisticated hand-powered systems. Improvements to low levels of productivity can have substantial effects in economic development.

Analyses of employment requirements indicate decreasing trends in Agnale in which substantial improvements to labor efficiency were assumed. Increasing labor requirements are demonstrated in all other cases; in both Chilalo and Setit-Humera higher levels of mechanization are employed in strategy II and, consequently, increases in labor requirements are smaller than labor increases in strategy I; in Tendaho, higher levels of mechanization in strategy II are accompanied by additional operations and consequently, increases in labor requirements are higher in strategy II than in strategy I. Absolute levels of employment are largest in the Tendaho case which involves highest levels of investment but, in the process of planning development, potentials for generating high levels of employment must be set in juxtaposition to the total investment requirements and the relative levels of anticipated net returns, rates of return, and anticipated average net returns to selected scarce resources.

Average gross product per unit of factors suggests a rising level of productivity for each factor. However, changes in the relative distribution of total product can only be estimated with more precise information on the production function than revealed by the investigations of this thesis.

In the analyses of potentials to earn or save foreign exchange, relative potentials for export or import substitution are high for Agnale and Setit-Humera although in absolute values Tendaho and Setit-Humera rank highest. When imported inputs are taken into account, greatest reductions occur in Tendaho in which imported equipment is relatively highest, next highest in the Setit-Humera case. In Tendaho, this net effect appears greatest in strategy I in which the value of the product (raw cotton) is considerably lower than in strategy II (ginned cotton), despite the total investment costs in imported equipment being greater in strategy II.

Analyses suggest greatest sensitivity to increasing total output values in cases of high investment relative to value of total product, i.e., the most pronounced effect is in Chilalo, strategy II (tractor hire). The effect of increasing labor costs are observed to be greatest in cases of low output relative to the quantity of labor employed, i.e., Chilalo, strategy II (tractor hire); Setit-Humera, strategy I (labor intensive); Tendaho, strategy I (raw cotton). Increasing discount rates appears to have greatest effect on those cases in which initial investment costs are relatively high and returns are initially low or delayed, i.e., in Agnale, where fruit bearing does not begin until several years after initial investment.

The greatest effect of raising foreign exchange rates appears to be in Chilalo, strategy II (tractor hire). In this instance returns to investments, a substantial amount being imported, are relatively quite small.

Data available to estimate anticipated price changes are scanty. Thus, at best, price changes employed to recompute the budget models can only be estimates of slightly increasing or slightly decreasing trends. In each case, modest increases in labor costs were assumed. The changes in values of benefit-cost criteria suggest that there is likely to be sufficient margin in the system to absorb labor cost increases in Agnale, Setit-Humera, and Tendaho. However, in Chilalo, strategy II, the higher level of mechanization leaves insufficient margin even at high levels of production to absorb significantly increasing trends in labor input costs.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Thesis Development

The first three chapters are largely introductory discussion designed firstly, to lay out the plan of the thesis and the role of mechanization in agricultural productive processes; secondly, to present a selection of socio-economic and environmental information about Ethiopia and her people in order to establish the macro-situation; and thirdly, to bring into focus those aspects of economic development which provide a context to relate micro-analyses of selected case studies to the macro-economic framework of the Empire. The fourth chapter presents the methodology employed in collection and analyses of data, concluding with the establishment of two sets of evaluation criteria: those to appraise the financial performance of proposals to invest in mechanization projects and those to be consonant with specified objectives of Ethiopian development planning. The fifth chapter contains brief descriptions of the four case studies (elaborated in Appendices A to D), and the sixth contains the analyses of data. The salient points of discussion, methodology, description, and analyses are presented in this summary.

Agricultural mechanization is defined as all forms of mechanical assistance used at any level of technological sophistication. This definition enables the technology observed in any given agricultural system to be categorized as: hand-, animal-, or engine-powered, each of which represents a different technological option open to economic planners.

The concept of mechanization in the dynamic context of economic development is manifested in six different operational processes:

1. Processes of improvement (within categories), (a) in hand-powered technology, (b) in animal-powered technology, (c) in engine-powered technology.
2. Process of transition (between categories), (a) from hand- to animal-powered technology, (b) from animal- to engine-powered technology, (c) from hand- to engine-powered technology. (Conceptually, transitional processes are reversible.)

The scope of the thesis is limited to analyses of four selected cases in which forms of mechanized technology may be introduced. Four dissimilar cases were selected, each having potential commercial viability, to demonstrate the procedure of economic analysis in dissimilar agricultural systems and the types of data required for these analyses. No generalized statements on agricultural mechanization in Equatorial Africa are attempted although the methodological approach has general application.

Thesis objectives are: (1) to present data relevant to mechanization from four cases of agricultural systems in Ethiopia; (2) to analyze these data to measure benefits, costs, and selected socio-economic changes which occur when mechanized technology is introduced into the selected systems; (3) to demonstrate by the methodology the types of information and data required to effect economic analysis; and (4) to demonstrate the application of the methodology to four dissimilar cases.

Relevant to Ethiopia's present level of development, and in order to maintain the scope of the thesis within manageable bounds, only mechanization possibilities of productive processes are examined. Agricultural mechanization is conceived as part of a complete system of agricultural production. Such an approach permits the analyses to take into account many of the variables relevant to the productive processes within a given socio-economic system.

The Ethiopian situation, providing the macro-context of the case studies, presents an extremely rugged and varied physiography over which a wide variation in climatic conditions obtains. The cases are selected from widely differing regions: Agnale Village, in the southwest some 1,000 kilometers from Addis Abeba, is located in hot, humid wooded savannah country; Chilalo Awraja, 150 kilometers south of the capital, is located in the temperate climate of the Central Ethiopian Highlands; Setit-Humera, 750 kilometers northwest of the capital, is located in a hot region where precipitation is relatively low; Tendaho Plantations are located some 580 kilometers northeast of Addis Abeba in the semi-hot desert of the Lower Awash Valley.

Agriculture contributes the largest single proportion to the Ethiopian gross domestic product and 85 per cent of all manufacturing is classified as agro-industrial. Trade imbalances, the needs to increase national levels of food production and foreign exchange are additional factors pointing to the importance of developing Ethiopia's agriculture.

The Third Five-Year Plan emphasizes agricultural development and gives high priorities to: early generation of cash incomes; economies in demands on scarce resources; correction of difficulties in land tenure arrangements; implementation of research; encouragement of private sector enterprises; improvement of agricultural institutions; extension of irrigation enterprises; expansion of production; expansion of agricultural mechanization and improved technology; expansion of bilateral and multilateral aid. Agricultural development is envisioned in two major strategies: (1) rapid development of modern commercial enterprises at an estimated annual rate of 5.7 per cent, and (2) expansion of the subsistence sector at an estimated annual rate of 1.9 per cent. The commercial sector of agriculture is expected to generate high income volumes, facilitate the establishment of new infrastructure, and provide local demonstration effects. It is anticipated that provisions will be made in the subsistence sector for extension and credit facilities, increased accessibility to markets, establishment of "package" input programs, and introduction of land reforms.

Methodology falls into four phases: field work, preparation of basic production data, data generation (preparation of budget models), and data analyses. Field work consisted of selection and observation of cases. Basic data were prepared from these observations to establish the initiating year for budget models employed to generate additional data for the analytical phases.

Selected cases depict agricultural systems employing different forms of mechanization. Each case contains potentials for developing a commercially viable production system through the introduction of cash crops, given adequate extension facilities. In selecting cash crops anticipated effective demand is taken into consideration, especially in existing systems producing largely for subsistence. Care was exercised to assume a form of mechanization appropriate to the resource endowments and relative factor prices for each selected system. No particular merit is vested in mechanization per se. The criteria for justifying processes of mechanization, either of improvement or transition, are economic involving both monetary and non-monetary values. Moreover, no assumption is made of a natural sequence in mechanizing productive processes by shifting from one level to another. It is assumed that an appropriate form of technology exists for a given system; appropriateness is construed in terms of local factor endowment and demands for different goods, services, and conditions. Both appropriateness and effective demand are subsumed under the condition of commercial viability.

The present organization of the Agnale Village case occupies all available labor at peak seasons. The climate affords two crop seasons: dry season (October to March) when maize, beans, and sorghum are grown; wet season (April to September) when maize and beans are grown. Approximately 72 hectares of land are double cropped over the year, i.e., crops and fallow total 144 hectares annually. The area is ideally suited to citrus crops which can provide the basis for an unsophisticated cash crop economy. Improvements are effected using improved hand tools, a simple irrigation system, improved storage facilities to reduce crop attrition, and one extension agent who, with adequate equipment, would be capable of supervising some 10-15 such villages (400-600 hectares).

The Chilalo Awraja case depicts a typical family farm of approximately eight hectares of land, a little over five of which are cropped in the present system. There is a one crop season (harvest December). Wheat, barley, maize, teff, flax (for linseed), peas, and beans are grown for subsistence and market sales. Two alternative strategies were assumed: strategy I, two extension agents operating service facilities for 150-200 farmers (1,200 to 1,600 hectares) to develop improved animal-powered technology; and strategy II, the same personnel operating facilities for 50 farmers (400 hectares) to develop tractor hire and extension services.

The Setit-Humera case depicts a typical 800 hectare farm operated by a private entrepreneur operating three tractors and growing sesame, cotton, grain sorghum, and beans on a commercial basis. In order to effect improvements, it was assumed that a small team of trained professionals (extension agent, research officer, finance officer--half-time), can provide extension facilities for 100 farmers (80,000 hectares). Two strategies were assumed: strategy I, only early tillage operations mechanized to maintain high levels of employment (migrant labor); and strategy II, operations subsequent to early tillage mechanized to employ engine-powered technology more intensively as a substitute for labor.

The Tendaho Plantations are being developed from a large land concession of 10,000 hectares devoted to cotton under a combined management of Ethiopian and expatriate technical personnel. In the initiating year, cotton is grown on 1,100 hectares; the area is expanded annually to take up the full concession. Technical services were assumed to be provided fully by the Plantation's professional staff. Two strategies were assumed: strategy I, early tillage operations mechanized to employ the minimum requirements of engine-powered technology to grow cotton in a plantation system; and strategy II, in addition to mechanized early tillage operations, establishment of a ginnery to increase the number of mechanized operations. Both strategies employ high levels of hand labor in weeding, thinning, and picking.

Following preparation of basic production data to establish the initiating year of the budget model for each case, a number of basic assumptions were made in order to prepare budgets over a 10 year period and later approximations over a 20 year period. Basic assumptions cover the following areas: subsistence requirements, yields for subsistence and cash crops, crop prices, levels of crop attrition during storage, tools and equipment, operational rates for labor and equipment, and establishment costs.

In order to introduce improvements to each system in the form of appropriate new levels of mechanization, additional assumptions were made with respect to extension and credit facilities based on annual interest rates of 8 per cent for crop loans, 7 per cent for overdrafts and medium- (7 years) and long-term (20 years) loans. In each case the financial accounts of the budget model presented in the Appendices are based on high and low production levels corresponding to high- and low-level yield possibilities. Both high- and low-level yields represent improvements on achievements observed in the field (1968). High-level yields were assumed achievable with efficient management, low-level yields for less than adequate management skills. In the initial budget computations, constant product and input prices were employed; in second computations price trends were assumed for cash crops and labor inputs. Also, in computing budget model data for the Agnale, Chilalo, and Setit-Humera cases, in which substantial proportions of outputs and inputs were observed to fall within the non-cash fraction of the system, the presented accounts maintain non-cash and cash flows separately. The budget models provide data for benefit-cost and subsequent analyses.

Analyses

The benefit-cost analysis technique facilitates the evaluation of anticipated financial returns and costs to investment proposals in situations where the market mechanism does not guide the flow of investment funds. This technique provides computed values for a number of selected criteria which form the basis for alternative decision-making rules: net present value (NPV), payback period (PB), internal rate of return (IRR), benefit-cost ratio (B/C), NPV per unit invested capital (NPV/K), NPV per unit salary cost for technical professional personnel (NPV/T_W), and NPV per unit salary and supporting costs for technical professional personnel (NPV/T_{WS}).

The IRR is a measure of the anticipated rate of return for capital invested in the project when capital investment costs are exactly repaid to investors. IRR enables comparisons to be made between projects in terms of rates of return to capital invested in each project.

The NPV for a mechanization proposal is the present value of anticipated stream of net returns after meeting all operating and capital costs incurred through the project period. Streams of benefits and costs are discounted to the initiating year (t=0). In the analyses of this thesis, the budget period employed was 10 years; the employed discount rate was 0.10, based on an estimation of the opportunity cost for capital in Ethiopia.

The actual size of NPV is a result of the combined effect of accounting prices employed for all outputs and inputs. Thus, NPV/K, NPV/T_W, and NPV/T_{WS} are each measures of anticipated net average returns when this net return is allocated for <u>one</u> arbitrarily selected resource (K, or T_W, or T_{WS}). These measures are devices for indicating those project proposals in which the selected resource is employed extensively.

Usually investment capital (K) is designated as the limiting resource. Any single resource can be selected arbitrarily as a limiting factor and, given an array of alternative investment proposals, selection would require a high value for NPV/K. In the Ethiopian situation NPV/T_W and NPV/T_{WS} were also computed because skilled technical personnel (wage costs: T_W, wage and supporting costs: T_{WS}) are probably scarcer than direct investment capital (K). Computed values are tabulated for these criteria obtained from the budget model data and 20 year approximations.

Four other criteria derived from specified non-monetary objectives in the development plans are employed in subsequent analyses. They are employed independently because they cannot be realistically conceptualized in monetary terms for incorporation into the benefit-cost analyses. These criteria are: generation of income, employment and distribution of income, productivity of factors, potential for export and import substitution. Changes in the values of these criteria were measured by index numbers at selected points in time over the budget period.

Benefit-cost analyses of data generated in the Agnale Village case study indicate very high internal rates of return (IRR), for both high and low production levels, and high anticipated average net returns to each of the arbitrarily selected scarce resources of capital (NPV/K), costs of salaries for technical personnel (NPV/T_W), and costs of salaries and support for technical personnel (NPV/T_{WS}). These analyses suggest that high potentials exist for increasing net benefit streams by introducing unsophisticated improvements into economies based on hand-powered technology, provided adequate supervision is available along with cooperation from the village elders and people in introducing new cash crops into the system.

Data from two strategies in the Chilalo case study suggest that only modest net returns (NPV) can be anticipated from high production levels, and low production levels lead to negative net returns. Benefit-cost analyses of Chilalo data suggest that: (1) high yields must be attained through relatively efficient management in order to avoid negative net returns; (2) improving established animal-powered technology leads to relatively higher net returns than introducing tractor hire facilities. The second conclusion appears to be derived from the much higher capital investment required in establishing tractor hire services and the concentration of unit extension services on fewer farmers. Also, the farm is small and fragmented with much effort devoted to the production of subsistence crops. Therefore, machine operational performances tend to be inefficient.

Benefit-cost analyses of data from two strategies in the Setit-Humera case study indicate high rates of return at both production levels, and high anticipated average net returns for each of the selected scarce resources (K, T_W, and T_{WS}). These results appear to be derived from a combination of features: the large-scale nature of this system; the ability of the entrepreneur to manage engine-powered technology; the spread of investment in extension facilities over an extremely large area of productive land. Anticipated net returns to strategy I (labor intensive) tend to be lower than those to strategy II (machine intensive) since additional economies are facilitated by the higher level of mechanization, achieved at the expense of lower rates of increase in employment.

Benefit-cost analyses of Tendaho data suggest high anticipated net returns and moderately high rates of returns for high production levels but negative net returns for low levels. This system requires heavy investment commitments which should be undertaken with caution if any uncertainty exists about yield attainments. Average net returns for each of the selected scarce resources (K, T_W, and T_{WS}), tend to be relatively low: administrative facilities and costs of supporting technically trained professionals are relatively much higher than in the other cases. Net returns to strategy II (ginned cotton) are higher than to strategy I (raw cotton) due to the higher value of the product. Higher employment levels are indicated in strategy II because of the additional operations of the ginning process.

Analyses of Agnale data demonstrate the most dramatic increases in gross and net incomes, and increases in cash percentage. This system is initiated from a low productivity level on a wholly non-cash basis; thus, dramatic increases due to technological improvements are demonstrated.

Analyses of employment requirements indicate a decline in the Agnale case, in which substantial improvements to labor efficiency were assumed. Increasing labor requirements are demonstrated in all other cases; in both Chilalo and Setit-Humera higher levels of mechanization are employed in strategy II and, consequently, rates of increase in labor requirements are lower than in strategy I; in Tendaho, higher levels of mechanization are accompanied by an additional operation (ginning) and consequently, increases in labor requirements are higher in strategy II. Absolute levels of employment are largest in the Tendaho case which also involves highest levels of investment.

Average gross product for factors of land, labor, and accumulated capital in operation suggests a rising level over the budget period for each factor. However, changes in the relative distribution of total product can only be estimated when more precise information is known about the relevant production functions.

Analyses of potentials to earn or save foreign exchange, relative potentials for export or import substitution are high for Agnale and Setit-Humera although in absolute values Tendaho and Setit-Humera rank highest. Taking necessary imports into account, greatest reductions occur in Tendaho, Setit-Humera is next; these two cases have relatively highest quantities of imported capital equipment.

Sensitivity analyses indicate highest relative changes toward increasing total output values (positive correlation with benefit-cost criteria) in cases of relatively low value of total product to total investment costs, the most pronounced effect is observed in Chilalo, strategy II (tractor hire). The effect of increasing labor costs (negative correlation with benefit-cost criteria) are observed to be greatest in cases of low output relative to the quantity of labor employed. Increasing discount rates (negative correlation with criteria) appeared to have greatest effect on those cases in which initial investment costs are relatively high and returns initially low or delayed. Thus, the effect appears greatest in Agnale where fruit bearing commences several years after the initial investments.

Raising the foreign exchange rate (negative correlation with criteria) has greatest effect in cases of small output relative to imported investments. Chilalo, strategy II (tractor hire) was affected to the greatest extent.

Estimates of anticipated price changes are not readily available. At best, price changes employed to recompute the budget models can only be estimates of slightly increasing or decreasing trends. In each case, modest increases in labor costs were assumed. Resultant changes in computed benefit-cost criteria suggest that increasing labor costs can be absorbed without difficulty in Agnale, Setit-Humera, and Tendaho. Chilalo, strategy II, data suggest that at the higher level of mechanization there is insufficient margin, even at high yields, to absorb increasing trends in labor input costs.

Conclusions

The intention to avoid substantive in contrast to methodological generalization was asserted in Chapter I. One case from each of four different agricultural systems is an inadequate basis from which to draw generalized conclusions for the technological improvement of similar systems or to designate the role that such improvement may take in the context of total Ethiopian development. However, methodological generalizations are admissible because they provide general guidelines for analytical procedures without anticipating any particular results.

Conclusions drawn from the analyses of each of the four case studies are presented first. They serve to point to the possibility of other useful specific, perhaps similar, conclusions being drawn from similar analyses of other cases. Specific conclusions from this thesis will serve as guidelines to what might be expected, and therefore what should be sought, in similar analyses. Methodological conclusions serve to suggest appropriate analytical procedures and the data required to perform the analyses.

Scale of Operation

Clearly, no common basis of comparison exists for the four selected cases in the basis of absolute quantities. In terms of the level of total income generated, total export earning potential, and the level of total employment, Tendaho Plantations rank highest. In terms of anticipated average net returns for investment (NPV/K), for wage costs of technical personnel (NPV/T_W), and for wage and supporting costs of technical personnel (NPV/T_{WS}), Tendaho does not rank high; in terms of average gross output, returns are relatively high to labor and land but relatively low to capital; in terms of employment of labor relative to land area the Tendaho case is relatively intensive but in terms of employment relative to capital investment Tendaho is extremely capital intensive--labor utilization per dollar of accumulated capital in operation is low. Average gross returns for land and labor in Tendaho Plantations are relatively high but those resources arbitrarily designated as scarce in the Ethiopian economy, i.e., K, T_W, and T_{WS}, display much higher average net returns in the Agnale and Setit-Humera cases. Neither case depicts an operation of comparable size to Tendaho but in its respective location each can be multiplied many times according to the extent to which that option is given necessary investment and technical support. The implication of these observations suggests that in the event of comparable scales of investment among these three cases, much higher average net returns for selected scarce resources can be anticipated in Agnale and Setit-Humera than in Tendaho.

Tendaho and Setit-Humera depict two forms of commercial agriculture employing sophisticated engine-powered technology. According to Ethiopian development plans, commercial agriculture is to be encouraged as the principal vehicle for rapid economic expansion and for achieving specified objectives of generating employment opportunities, facilitating the establishment of infrastructure, and creating opportunities for local demonstration effects.

Tendaho depicts a case in which the realization of these specified objectives can be reasonably assured. On the other hand, the Setit-Humera case can facilitate the objectives of rapid commercial development only if the government is prepared to promote the development of appropriate infrastructure. Thus, a conflict of policy may arise between allocating investment funds to the Tendaho case, and allocating funds to provide the necessary infrastructure in the Setit-Humera region. The former option offers the opportunity to achieve most of the specified developmental objectives at the expense of relatively low average net returns for the arbitrarily selected scarce resources; the latter offers the opportunity for rapid commercial expansion and relatively high average net returns for these resources, given adequate investment in infrastructure by the government. Such conflicts in objectives must be carefully examined in the course of economic analyses.

Agnale depicts an unsophisticated hand-powered system containing potential for substantial increases in both non-cash and cash forms of incomes and in exportable production. The system is initiated at a low level of productivity and the improvements are relatively unsophisticated. Such improvements can have a substantial impact on total development of the economy when the single case is multiplied many times according to the total investment level for the region. Relatively low investment requirements for each case enable development funds to be spread over a large sector of the economy in which relatively high levels of net return can be anticipated.

In the course of planning development, the pragmatic approach to agricultural mechanization is likely to include some combination of available forms of mechanized technology. Before new proposals are effected their evaluation from two different aspects is important. Firstly, the potentials of large-scale operations are to be set in juxtaposition to total investment requirements, the relative levels of anticipated net benefits and rates of return. Secondly, since a substantial proportion of Ethiopia's population makes its livelihood in unsophisticated hand-powered systems, an appropriate weight must be assigned to a mechanization proposal according to the size of the sector for which the improvement is proposed. Sophisticated mechanized agricultural technology in commercial operations facilitates the development of large-scale enterprises. Increases in scale, however, increase investment costs, management costs, and costs of additional technical facilities which may tend to depress returns to certain scarce resources. In contrast, modest investments in improved forms of unsophisticated mechanized technology in those systems where the majority of Ethiopians makes its livelihood may be substantial. Knowledge of such differences among proposals can only be determined accurately through the employment of appropriate analytical procedures prior to policy decision-making.

Alternative Forms of Mechanization for Small Farm Systems

The term "small farm" has been used throughout this thesis to refer to small-scale agriculture employing any of the three forms of mechanized technology. Two strategies employed in the Chilalo case depict the improvement of extant animal-powered technology (strategy I) or the provision of a tractor hire service (strategy II). These two strategies represent alternative forms of mechanization for the Chilalo farm system.

At the farm level, and at high yields, the budget analyses suggest that the tractor hire service alternative proves somewhat more profitable than the improvement of oxen technology. At low yields, however, negative net returns for the tractor hire service alternative are anticipated to be substantial while net returns for oxen-powered agriculture are anticipated to remain positive although substantially reduced from high yield returns. At the government level, benefit-cost analyses which include costs incurred by government support to the proposal in addition to farm level costs, suggest that anticipated net returns and internal rates of return for improved oxen technology are considerably higher than the tractor hire alternative.

Two major conclusions emerge from the analyses of the Chilalo case:

1. Although at the level of accounting employed for the farm (budget analyses) the tractor hire service appears profitable to the farmer who can anticipate high yields, at the level of accounting employed by the sponsoring institution, usually government (benefit-cost analyses), the tractor hire service promises lower returns to this small farm system than the proposal to improve extant animal-powered technology.
2. Yield levels are critical to these analyses and may have a predominating effect over the successful introduction of new forms of technology. This conclusion is discussed in the following section.

Given analyses indicating this situation, a decision to introduce a tractor hire service into Chilalo under the conditions represented by the analyses can only be made as a positive decision if policy-makers intend to adopt this form of technology as a means of introducing a subsidy to the area, a form which tends to use available resources uneconomically. Such a decision is frequently made in this sort of situation with the objective of increasing the power available for the cultivation of small farms. The Chilalo case study appears to offer no economic grounds to support such a program.

The following reasons may be posited from this case study to serve as guidelines for the analyses of similar cases. The farm in this case study is small and fragmented; thus, tractor and machine operating efficiencies are low. In this region, farmers' skills are generally inadequate to manage the problems of engine-powered technology without substantial supervision; therefore, the services of technically trained professionals are employed much more intensively than in the strategy improving oxen technology. Capital investment requirements per operating unit (50 farms) is considerably more intensive than that required to improve oxen power (150-200 farms).

Critical Yield Levels

The analyses of Chilalo and Tendaho cases suggest anticipated negative net returns for low production levels in contrast to positive returns for the same situations at high production levels. Low production levels are based on low yield assumptions due to less than adequate management and/or inferior agronomic conditions. Thus, yield attainments in these cases become critical in determining whether anticipated net returns are positive or negative.

Anticipated net returns for investment in the Chilalo case are only modest under the most favorable assumptions. Thus, it appears prudent to implement improvements which are not heavy in capital investment and in which scarce resources can be employed extensively in order to avoid risk of inadequate yields to realize sufficient net returns to meet relatively heavy investment costs.

Tendaho analyses anticipate substantial net returns to high production levels in both strategies and substantial negative net returns to low production levels in both strategies. The Tendaho case involves very heavy investments for which returns are inadequate if low yields are realized.

Whenever yield attainments are low, or there is doubt about the adequacy of yields to anticipate adequate net returns for the investment proposal, the adoption of the proposal, especially when investments are very heavy, should be considered imprudent. The same resources can be made available for employment in programs which promise more favorable net returns. Proposals should be carefully analyzed to determine the extent to which yield levels are critical and, if sufficient data are available, the expected distribution of crop yields around averages.

Anticipated Net Average Returns to Selected Scarce Resources

Three resources have been selected for special consideration throughout these analyses: capital, costs of salaries for technical personnel, and costs of salaries and supporting services for technical personnel. This selection is somewhat arbitrary for the purposes of the benefit-cost analyses since any resource is relatively scarce, unless it is a free commodity. These three resources were selected as scarce in the Ethiopian development situation. The benefit-cost analysis technique measures discounted average net returns to each selected scarce resource. The technique enables crude comparisons to be made among different investment proposals in terms of anticipated average net returns to each selected resource.

Investment capital is considered a scarce resource insofar as, in the development of the economy through special projects, capital has to be raised on local capital markets or negotiated through bilateral or multilateral aid arrangements. However, the potential for capital accumulation which exists in the economies of millions of small farmers through the creation of unsophisticated working equipment should not be overlooked. Such capital accumulation can be encouraged by policy decisions which favor cash crop production and enable small farmers to accumulate economic surpluses.

Costs of employing technical personnel, and the supporting costs necessary to maintain these personnel in the field are essential to the management of new agricultural projects. In the Ethiopian situation, the resources represented as investment in technical personnel to supervise projects are probably scarcer than direct investment capital.

With respect to invested capital, higher average net returns are anticipated in the analyses of data from Agnale since capital requirements are relatively low. With respect to costs for technical professionals, highest average net returns are anticipated in the analyses of data from the higher level of mechanization alternative (strategy II) of Setit-Humera, followed by the lower level of mechanization (strategy I) since these service facilities are spread over production from an extremely large agricultural area.

This device of the benefit-cost analysis technique serves to indicate the projects in which designated scarce resources are employed extensively. The results are useful insofar as the criteria encourage the selection of investment proposals to which average net returns to these resources are anticipated to be highest.

Indications of Sensitivity Analyses

Greatest changes occur with respect to changes in total product. The observations suggest that a combination of changes in crop yields and product prices is likely to have the most significant effect on results of this form of economic analysis and, therefore, the accuracy of these data is most important in the preparation of budget models. In cases for which computed anticipated net returns are initially low, the relative change in computed values of benefit-cost criteria are much greater than in cases of relatively high values in initial computations.

Increasing the labor input has the most marked effect in two groups of situations: (1) cases in which labor input is relatively high, i.e., Setit-Humera (both strategies) and Chilalo (strategy I); (2) cases in which returns are relatively small (any change in input costs appears relatively large), i.e., Chilalo (strategy II). In such cases careful inquiries must be conducted into labor operational requirements and scope for increasing economies in labor utilization in the event of wage increases.

Field Observations and Data Transference

The preparation of budget models used in this thesis necessitated the use of a large amount of technical and economic data relating to each case. Field observations were conducted and the systems were simulated for the initiating year on the basis of these observations. However, little accurate data were available for average agricultural practice in any of the regions in which the cases are located. The best available data were provided in the Chilalo Awraja where the Chilalo Agricultural Development Unit of the Swedish International Development Agency has conducted numerous agricultural surveys. In this region the results of some variety and fertilizer trials were available and were employed in preparing the budget models. Little information was available, however, on local labor and machine operational rates, or on the use of improved agricultural equipment. Many of the assumptions for yield data, seed rate requirements, cultivation requirements, labor and machine operational requirements used in Setit-Humera and Agnale were based on estimates available in publications of the Stanford Research Institute in which data transferred from similar ecological conditions found in the United States have been employed. Wherever possible such estimates were modified according to observed experience in Ethiopia. In the case of Tendaho, the budget model presented in this thesis is the result of data and financial information being made available from the working accounts of the company.

There is no substitution for actual field observations of agricultural research conducted in the country, and in the particular region, for which developmental changes are proposed. Estimation of total output, demonstrated by the sensitivity analyses to be the most significant single item affecting the value of the benefit-cost criteria, is determined by crop yields, product prices, and quantity of marketed production. Of these components, yields in many instances were estimated using formulae which adjust actual experience for changes in environmental conditions; prices employed were those obtained from interviewed farmers or Stanford Research Institute estimates, market records being unavailable; rates of product attrition were estimated rather than the experience of controlled observations.

Data on currently practiced cultivation techniques were only available to a limited extent from experimental stations. These had to be adapted to local conditions. Data on new or improved practices were virtually unavailable and had to be approximated.

In the study of mechanization, testing a range of available equipment to determine most suitable equipment and its operational capacities under prevailing conditions is essential to achieve accurate economic investigations of farming systems. These data only become available systematically as suitable agricultural equipment is tested under appropriate conditions.

Thus, the data and procedures employed in this thesis serve a three-fold function. First, to give approximate answers to questions about the relative benefits and costs from changing forms of mechanization in the selected cases; second, to demonstrate the analytical procedures and the data required in the process of these analyses; third, to provide approximations of technical data, used as assumptions in this thesis, which can be tested and adjusted as future research provides more accurate estimates for local production conditions.

Agricultural Credit Facilities

In the preparation of budget models credit facilities were assumed for medium- and long-term loans at annual interest rates of 7 per cent and crop loans at annual interest rates of 8 per cent, charged monthly. Net negative balances were accommodated as overdrafts at an annual interest rate of 7 per cent.

Clearly, the workability of the budget models is dependent on adequate credit accommodation. There is little realism in any proposal to improve small farm systems unless adequate credit facilities are available. In certain cases, large-scale commercial undertakings are able to finance themselves. However, in the Ethiopian experience the large-scale undertakings have been able to obtain bank accommodation more readily than small farmers, a situation which tends to mitigate against widespread rural development.

Sociological Implications of Budget Technique

In the justification of the budget technique commercial viability of each selected case was assumed. However, the sociological implications of increasing cash incomes cannot be overlooked in the development of a system into a commercially viable unit.

Commercial viability assumes willingness of the individuals in the system to cooperate in change. Much responsibility for the success of development rests on the technically trained professionals in immediate contact with the local people. As the development process continues, cash incomes of the local people will gradually increase. Increasing availability of consumers' goods and services must be fostered as increasing cash incomes is part of the development process; it also is a means of strengthening the position of those in immediate contact with the local people since, ultimately, these local people require adequate encouragement to desire the continuing increase of cash incomes.

Recommendations

Data, analyses, and conclusions of this thesis have been prepared in order to provide agricultural policy-makers and planners in Ethiopia with information to aid decision-making with respect to mechanized technology. Such information contributes to broadening the base of knowledge on which decisions can be taken.

Policy decision-making embraces a much wider range of considerations and seeks a wider base of knowledge than can be provided by a single thesis. However, the investigations and subsequent analyses of four case studies in Ethiopia can be a useful contribution insofar as economic implications of policies to mechanize agricultural practices are brought into sharper focus. These analyses serve to indicate the kinds of questions that can be put to investigators engaged in economic research. In the process of investigation and economic analysis of agricultural mechanization, the investigator asks questions about this particular area of research; the information gained may be useful in answering questions of concern to policy-makers. When these two groups of professionals put questions to each other, part of the policy decision-making process moves into dialogue between policy-makers and investigators. In this way investigators can discern more quickly the type and organization of information relevant to policy-making and, in turn, policy-makers can be provided with information congruent to their needs. Research and policy-making then become continuing processes each providing information to and guiding the other to relevant areas of mutual interest through the process of continuing dialogue.

The recommendations which conclude this thesis are presented as areas of investigation which appear, in the light of research undertaken for this thesis, to be of particular interest to policy-makers concerned with the process of improving agricultural technology in Ethiopia by mechanization. Recommendations relate to the following five areas: (1) questions about the role of agricultural mechanization; (2) specific questions about selection and implementation among alternative mechanization programs; (3) project appraisal; (4) project establishment; (5) research organization and priorities.

Questions about the role of agricultural mechanization are posed anticipating answers which will provide useful information and insights for the development of related policy. Such questions are important because they are used to guide relevant research. The general question, what role does mechanization play in the development of the agricultural sector of the Ethiopian economy, is too broad to provide answers except in equally broad terms. The discussion of technical relationships in Chapter I of this thesis provides the general terms for answering this question. Conceptually, mechanization is a means of changing the form and amounts of capital employed in the production function: a process referred to as technical progress. This process involves higher production costs, therefore necessitates higher productivity. Thus, insofar as increasing production costs involves raising cash expenditures, commercial viability is a prerequisite to mechanization.

Therefore, it is recommended that to guide the planning of agricultural mechanization in Ethiopia general policy questions be couched in terms of already established policy objectives, e.g., the role of agricultural mechanization in changing employment level, or in improving income generation and distribution. Such questions may be posed for the total economy or for selected regions. They are questions which necessitate a continuing research program in which specified objectives of development plans are employed as evaluation criteria for proposed projects. As proposed projects are approved and implemented, an increasing accumulation of technical data can be anticipated. The usefulness of a continuing research program for general policy-making lies in the feedback process by which objectives of development plans are employed as evaluation criteria and, in turn, are themselves tested for feasibility against the findings of research.

Specific questions about selection and implementation among alternative mechanization programs relate to the form of technology and location for investment proposals. Location must be considered among sectors of the agricultural economy as well as the geographical selection of sites for specific mechanization proposals. The objectives of Ethiopian development plans place heavy emphasis on commercial agriculture. The analyses of this thesis indicate certain forms of commercial operations employ scarce resources less efficiently than small farm systems. Relative merits of different proposals should be tested by careful analyses and it is recommended that no proposals be implemented without such prior analyses.

The benefit-cost analysis technique specifically draws attention to projects in which arbitrarily selected scarce resources are employed extensively. In this thesis such cases are those in which technological problems associated with the form of mechanization are within the competency of the farmer to solve and manage, given necessary extension facilities. In this way the government is responsible only for the provision of effective services for extension, credit, research, and necessary infrastructure to support the region's economic development; the farmer handles daily problems of management without requiring the close involvement of extension agents. Within the bounds of the recommendation to employ capital and the services of technically trained personnel extensively wherever possible, the question of sites for new projects should be examined both from the viewpoint of rapidity of development and the size of agricultural population for which the selected form of mechanization, when developed, will provide an appropriate learning experience. Commercial forms of mechanized technology are generally more rapidly adopted where technical competency is adequate. However, the introduction of technology appropriate to the Ethiopian small farmer and the learning experience afforded by any single project are likely to have much wider impact on the Ethiopian economy in the long run.

Project appraisals should be carried out as economic analyses taking into account both financial net returns and non-financial effects of project proposals. Tests should be applied to check for consistency between any proposal and relevant objectives of economic planning. The analyses of this thesis serve to illustrate economic analyses of four projects. Such analyses are facilitated by availability of relevant economic and technical data. Data transference tends to weaken the validity of analyses although such analyses are preferable to none at all since they provide a synthesis of functional interrelationships of a selected case and bring into focus data needed to improve accuracy of analyses.

Project establishment necessitates the employment of appropriately qualified technical personnel. The field experience of gathering data for this thesis afforded ample opportunity to observe both apparently successful mechanization projects and the results of unsuccessful projects. Extensive utilization of technical professionals has already been recommended; from the experience of observations in the field, it is recommended that no project be undertaken if availability of technical staff is inadequate. Adequacy of supply should be interpreted as including provisions for easy consultation between professionals on daily problems of the project, adequately trained assistants, and provisions to permit the occasional absence of the principal technical professional from the site of the project without adverse repercussions in daily operations.

The inadequacy of data relevant to mechanization in the productive processes has been very apparent during the course of preparing and generating data for this thesis. It is therefore recommended that: new research endeavors be encouraged to improve the availability of relevant data within the Ethiopian Empire; systematic records be maintained of all ongoing projects; records of aborted projects be preserved and made available for research purposes. Over time, this will reduce the need for data transference; thus, improving accuracy of economic analyses and efficiency in their execution.

Three general areas of research are relevant to problems of agricultural mechanization: (1) research within the technical disciplines of agriculture, i.e., biological and engineering research; (2) research within the discipline of agricultural economics, i.e., case studies and system analyses falling within the province of farm management research; local, national, and international price and demand studies for Ethiopian commodities; (3) policy level research designed to ask questions about the relevancy of mechanization in the total context of Ethiopian development. All three areas need to be placed on a continuing basis coordinated through an appropriate institution (presumably the Institute of Agricultural Research).

The area of farm management research offers much scope for student papers and master's theses as single and complete study pieces. Such work can be coordinated through collaboration between the Institute of Agricultural Research and the Alamaya Agricultural College of Haile Selassie I University.

It is recommended that the total continuing research program be coordinated on a systematic basis by a panel of Ethiopian and other invited professionals each competent in a relevant area of investigation: biology, agricultural engineering, and economics. Each of these disciplines includes professional skills for which others have no plausible substitute. The economist is not equipped to determine many of the technical conditions of productive systems, nor to determine which of a range of available machines, or of available plant varieties can be used in any given system. On the other hand the economist can, and should be expected to, play a leading role in suggesting to engineers the systems and the form of mechanization within these systems, and to the biological scientists the crops and crop combinations, which are likely to be most fruitful areas of inquiry from the point of view of social benefits and the stated objectives of Ethiopian plans.

APPENDICES

APPENDIX A

AGNALE VILLAGE CASE STUDY

APPENDIX A

AGNALE VILLAGE CASE STUDY

Introduction

Agnale Village, approximately 1,083 kilometers from Addis Abeba in the Province of Ilubabor, has been selected as a case study of a hand-powered farming system in which the introduction of technological improvements is limited to hand-powered forms of mechanization. Animal-powered technology is unfeasible because of tsetse fly infestation and engine-power is inappropriate to the peoples' present unsophisticated technological understanding of agricultural production and marketing.

Gambela is the area's principal town where there are river port facilities including warehouses and an air-field. Agnale's location is approximately 50 kilometers west of Gambela, close to the northern bank of the Baro River (latitude 8°15' North, longitude 34°0 East) which flows westward to join the White Nile in the Sudan. The altitude at Agnale is approximately 450 meters; the terrain slopes away toward the Sudan and the Ethiopian Highlands begin to rise steeply about 80 kilometers east of Agnale: Gore, some 160 kilometers east lies at an altitude of 2,005 meters.

The terrain in the vicinity of Agnale is described as open woodland and savannah,[1] drained by the Baro which floods annually during the rainy season (June-October). The red soils range from a deep clay to sandy loam. The soil's organic matter, its slight acidity with high available phosphorus and low salt content is favorable for most crops. The main subsistence crops are maize, grain sorghum and haricot beans. The Agnale area is "the most favorable for crop production of any soils tested from the study sites of Ethiopia."[2] Under current agricultural practices,

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[1] Zerom, op. cit., p. 19.

[2] Kline, et al., op. cit., Pt. II, pp. 36-39.

there is little difficulty in growing adequate crops although a short "hunger period" occurs before the second harvest in the middle of the rainy season.

Agnale lies between the 1,000 and 1,400 mm. isohyets, having a mean annual precipitation of 1,100 mm. The assumed data shown in Table A.1 for rainfall and temperature have been adjusted from data for proximate recording stations.

Fieldwork observations have provided data to establish the initiating year (t=0) of the budget model. The economic balance of the system in its existing organization insures adequate production along with an acceptable annual distribution of leisure. Labor requirements during January-March render additional cropping impossible during the dry season. There are fewer available demands on labor during the wet season but any proposals to increase the production of subsistence crops are unlikely to be received enthusiastically since there is no market for surpluses. Thus, proposals for technological improvement at Agnale are aimed at economizing in labor utilization with a more even distribution of labor use in order to employ the released labor to produce high value cash crops such as citrus fruits.

Proposals to introduce higher yielding varieties of subsistence crops are included in the model but the main intent is to reduce the area under cultivation in order to release labor to cultivate cash crops. Mechanization in the form of improved hand tools will increase labor productivity in peak demand periods. This type of mechanization becomes a realistic possibility only if adequate instructional facilities, infrastructure, and an appropriate market to realize economic returns to meet increasing production costs can also be provided.

Present Agricultural Economy

The People and Their Habitat

The people of Agnale Village are Anuaks, a Nilotic group with a closer ethnic affinity to certain Sudanese groups than to the predominant Ethiopian ethnic groups. Agnale and the other nearby villages in which these Ethiopian Anuaks live are situated close to the river on the higher banks which remain above flood water level when the hinterland becomes submerged. The river banks are intensively cultivated; the hinterland is left uncropped. Village compounds are surrounded by thicket hedges; each family lives in one or more grass-walled and thatched circular houses.

TABLE A.1 Agnale: Climatic data and distribution of crop operations by calendar months, budget model initiating year (t=0)

Item	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
Seasons	------------	------------	Dry	------------	------------	------------	------------	------------	------------	Wet	------------	------------	
Mean rainfall[a] (mm.)	85.0	34.7	12.5	3.0	11.9	22.2	58.9	130.3	142.6	185.9	243.6	169.4	1,100
Mean temperature[b]													
Maximum (°C)	32.8	33.7	33.6	35.0	36.1	35.9	34.5	33.4	31.7	30.4	30.6	31.7	
Minimum (°C)	22.6	23.0	23.1	23.3	23.8	23.8	23.8	23.1	22.3	22.2	22.4	22.3	
Crop operations and labor requirements in man-days per plot[c]													
Maize--operation	clear	plant		weed	harvest	clear		plant	weed		harvest		
--labor	17(±3)	3(±1)		17(±3)	3.5(±.5)	17(±3)		(3(±1)	25.5(±4.5)		(3.5(±.5)		89.5(±16.5)
Sorghum--operation			clear	plant	weed		harvest	mature					
--labor			17(±3)	19.5(±8.5)	22(±8)		5(±1)						63.5(±20.5)
Beans--operation			plant	weed	harvest			plant	weed	harvest			
--labor			1	1	1			1	1	1			6.0
Total labor													
Minimum	14	3	40		32		6		23		4		122
Average	17	4	54.5		43.5		8		27.5		4.5		159
Maximum	20	5	69		55		10		32		5		196
Total labor available	31	30	31	31	28	31	30	31	30	31	31	30	365

[a]Calculated from data recorded at Gambela (1947-1956) showing total mean annual rainfall of 1405.1 mm. Huffnagel, op. cit., p. 64.

[b]Calculated from data recorded at Gore (1953-1957), temperature adjusted by +10.11 °C for altitude change in the same region 2,005 to 450 meters. Ibid.

[c]Plot sizes: maize, 0.8 ha.; sorghum, 0.7 ha.

No census has been taken in the Gambela Awraja (sub-province)[1] but local Christian missionaries estimated the village to contain about 20 families. The village elders who control all village affairs, reported a total of 48 actively working men and boys. These estimates suggest a total of 190 persons; census data for other sub-provinces in the area indicate a natural rate of increase of 10.9 per thousand.[2] This rate of population increase provides the basis for determining the subsistence crop requirements recorded in Table A.2(a).

No legal titles to land exist; these people have title by custom after several generations of settlement. No rents are paid for any land.

Agricultural Practices

On request men and boys (12 years minimum) are allocated fields by the village elders. Fields are subdivided into plots which range from 0.6 to 1.0 hectares for maize and 0.6 to 0.8 hectares for sorghum. No obvious divisions exist between fields, nor is there any attempt to arrange for members of the same family to work together or in close proximity. Both maize and grain sorghum are grown in the dry season; in the wet season only maize is grown and the remaining land lies fallow. These observations suggest that 72 hectares of land are under main crops.[3] A few minor crops are fitted into the cultivation pattern: haricot beans, gourds, pumpkins, sesame, and cotton were observed.

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[1] Imperial Ethiopian Government, Report on a Survey of Illubabor Province, National Sample Survey, Report No. 11 (Addis Abeba: Central Statistical Office, June, 1968), p. 4.

[2] *Ibid.*, p. 18.

[3] Dry season:

48 plots of maize,	0.8 ha./plot	=	38.4 ha.
48 plots of sorghum,	0.7 ha./plot	=	33.6 ha.
48 fields	1.5 ha./field	=	72.0 ha.

Wet season:

48 plots of maize,	0.8 ha./plot	=	38.4 ha.
48 plots of fallow,	0.7 ha./plot	=	33.6 ha.
48 fields	1.5 ha./field	=	72.0 ha.

TABLE A.2 Agnale: Basic assumptions

a. Population, numbers of workers, subsistence crop requirements, inventory of equipment, and total annual capital expenditure, budget model (t=0,...,10)

Year	Population	Workers	Subsistence crops			Tool sets			Storage cribs		Knapsack sprayers	Hand pumps	Total capital expenditure
			Maize	Sorghum	Beans	Old tools[a]	Other tools[b]	Improved tools[c]	Old cribs[d]	New cribs[e]			
	-----numbers-----		---------quintals---------			----------------------------numbers----------------------------							dollars[f]
0	190	48	790.40	297.43	7.00	48	48	-	60	-			-
1	192	49	798.55	301.30	7.07	42	49(48)[g]	12	45	16	(6)[h]	(2)[i]	2,507.86[j]
2	194	49	807.42	303.05	7.15	36	49	24	30	28			1,590.46[j]
3	196	50	815.83	306.96	7.22	30	50	36	15	49			1,901.84[j]
4	198	50	823.85	309.96	7.30	24	50	48	-	70			147.60[j]
5	200	51	832.28	313.17	7.37	18	51	62	-	71	(6)[k]		31.20
6	203	51	844.48	317.70	7.48	12	51	62	-	74	5[l]	(2)[m]	18.00
7	205	52	852.80	320.80	7.55	6	52	64	-	74			99.60
8	207	52	861.12	324.00	7.63	-	52	64	-	75			78.00
9	209	53	869.44	327.00	7.70	-	53	66	-	76			135.60
10	212	53	881.92	331.00	7.81	-	53	66	-	77	5[n]		132.00

[a] Challa, valued at $0.80 each; average life of 8 years (depreciation: 12% p.a. of original cost).

[b] Machete, valued at $0.80 each; average life of 10 years; knife, valued at $0.40 each, average life of 5 years. Cultivator replaces these as required out of own cash income--excluded from capital expenditure.

[c] Planter head and handle, improved hoe head, valued at $1.80 per set, average life of 12 years.

[d] Valued at $3.60, depreciated at $0.91 p.a. [e] Valued at $6.00, depreciated at $1.00 p.a.

[f] All dollar values for these analyses are U.S. dollars.

[g] Hand tools for citrus orchard cultivation, valued at $1.50 each (depreciation: 12% p.a. of original cost). Items in parenthesis are included in establishment costs.

[h] Valued at $32.00, cost and provision for replacement included in citrus establishment costs (depreciation: 25% p.a. of original cost).

[i] Valued at $50.00 each, cost and provision for replacement included in establishment costs (depreciation: 20% of original cost).

[j] Includes establishment costs from part "e" of this table.

[k] Replacements (provided for in establishment costs).

[l] Valued at $32.00 each, for use in subsistence crops (depreciation: 25% p.a. of original cost).

[m] Replacement pumps (provided for in establishment costs). [n] Replacements.

In the established agricultural system tools and equipment are unsophisticated, entirely hand operated. The principal tool is the challa, a short, straight, wooden-handled hoe about 60 cm. in length. The narrow iron blade (13 cm. long x 6.5 cm. wide) continues in the same line. The blade is obtainable in Gambela for $0.80.[1]

The challa is used in a crouching position for cultivation and weeding. In weeding the challa is used along with a homemade long wooden hook, the diagano, to rake up the weeds.

There are a number of other general purpose tools observed in use: machete (price in Gambela, $0.80) used for clearing tall grass; knives (price in Gambela, $0.40) used for cutting off grain heads during harvest; and chisels, spearheads, and fish hooks which can be fashioned in wrought iron by the village blacksmith. The chisels are used to hollow out tree trunks for canoes used in fishing and general transportation.

The distribution in the annual calendar of crop operations along with estimates of labor requirements are shown in Table A.1. Precultivation consists of clearing residues left from previous crops. The ground is then roughly broken, but not turned, prior to planting; weeds and roots are also removed at this time.

The two planting seasons are in November, following flood subsidence, and in April. Maize is planted in a zig-zag pattern by women who drop five or six seeds into holes made by the men using a challa. A foot movement covers the seeds with soil. Sorghum is planted by the men who place 10 or 12 seeds with a little water into a hole around which the soil has been carefully pulverized.

Weeding follows planting. Ideally, maize is weeded three times during the wet season and twice during the dry. Weeding sorghum is tedious and there is only time for one weeding.

Maize is harvested by digging up the stalks with a challa. Stalks are laid in rows and the cobs from the day's harvest are shucked by the women who carry them to the village in large baskets to dry or to be shelled. Shelled grain is then dried and stored in the cribs.

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[1]All dollar values are U.S. dollars.

Sorghum is harvested in April. The harvest procedure is similar to that for maize. During the maturation period the sorghum crop must be carefully protected from birds by boys and men.

Crop labor requirements have been estimated on the assumption that each individual cultivator is solely responsible for the crops in his own plots. These data, contained in Table A.1, are the amount of work required annually of each active man; the sum of labor requirements identifies those periods when labor requirements are critical, i.e., in December and January.

Seed is saved annually by each family. Crude estimates of seed rates were established at 20 kilograms per hectare of viable maize grains and 14 kilograms of viable sorghum grains. There are no other inputs required by the agriculture in current practice.

Production and Value of Subsistence Crops

Estimates of maize yields for the wet season were made by random selection of ripe cobs. Allowing for 10 per cent moisture content,[1] maize yields approximate 20 quintals per hectare, suggesting about 15 quintals per hectare in the dry season. An estimate of 18 quintals per hectare appears reasonable for grain sorghum (slightly higher than observed yields in Setit-Humera where soils are somewhat less fertile and rainfall a little lower).[2]

Annual grain production, estimated on the basis of these yields, appears adequate for 213 adults for one year, enough and a little to spare (for seed, guests, and beer-making) to provide the estimated population with two staple cereals. This conclusion is reached as follows: Assuming 40 per cent loss in storage, maize available for consumption amounts to 806 quintals.[3] Assuming 50 per cent

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[1]Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 92.

[2]*Ibid.*

[3]Annual maize production

Dry season:	38.4 ha. x 20 q/ha.	=	768.0 q.
Wet season:	38.4 ha. x 15 q/ha.	=	576.0 q.
			1,344.0 q.

loss, sorghum for consumption amounts to 302 quintals.[1] According to a rule of thumb used by local missionaries, one adult requires 10 kilograms of grain weekly; 1,108 quintals will feed 213 adults for 52 weeks.

Supplements to cereals are obtained in two crops of haricot beans totaling about one hectare each and other minor crops. In addition, a substantial quantity of fish is obtained from the river. Beans and sesame crops are grown in small plots; a discussion of the method of estimating yields for these crops follows below.

No marketable surplus is produced at Agnale. A small quantity of grains and pulses may change hands for cash at seed times and other times of relative scarcity. A common price for grains is $4.00 per quintal, in times of scarcity prices rise to $10.00 and even above. Bean prices were estimated at $6.40 per quintal, 60 per cent higher than cereals.

Technological Improvements

Mechanization in this unsophisticated agricultural system is construed in terms of improved hand tools. Other unsophisticated technological improvements, however, can also be incorporated into the system in order to improve its efficiency and draw it closer to the cash economy of the nation. These improvements include: improved grain storage facilities, new crop varieties, the inclusion of high value cash crops, and the use of a simple crop protection program.

The introduction of such improvements must follow a workable sequence. Any increases in crop production can only be handled by reducing and improving the distribution of labor requirements since bottlenecks have already been observed. This can be achieved by simultaneously improving labor's efficiency, and reducing the level of attrition, thereby reducing the required area of subsistence crops. The introduction of improved hand tools and storage facilities involves some cash expenses and, therefore, some cash surplus must be generated as quickly as possible.

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[1] Annual sorghum production
Dry season: 33.6 ha. x 18 q/ha. = 1,344.0 q.

The area is ideally suitable for citrus fruit production which can form the basis of cash crop production. The following proposal is made in order to effect a gradual change from a completely subsistence to a partial market economy in a workable sequential order of technological improvement:

> An area of simply irrigated citrus orchards is to be incorporated into this system simultaneously with the introduction of improved storage facilities and hand tools. Since citrus trees do not begin to bear fruit until the fourth year after planting, an area of sesame, a crop with which the people are already familiar, is also to be established as another cash crop. Sesame is a valuable annual cash crop and can provide a cash income to cover the additional costs incurred in obtaining improved equipment, assuming the initial cash outlays can be covered by a medium-term loan.

Hand Tools

Two improved hand tools have been designed for use in this area: a hollow shaft for the challa to convert it into an efficient planting stick; a heavier wide bladed right-angled hoe for cultivation. These tools have already been used experimentally and cultivators are interested in using them. Efficiency in labor productivity can be assumed to be doubled in those operations where the improved tools are employed, i.e., planting, cultivation, and weeding.[1]

New tools are to be purchased in small installments as old tools are replaced. Twelve sets of new tools are to be purchased annually, to equip 10 workers. Each set of tools consists of two metal heads and the hollow handle, manufactured at the agricultural school workshop at Jimma for a cost of $1.80 at the village. The second hoe handle can be made locally at no cost.

Grain Storage

Each of the 60 grain storage cribs observed had an average capacity of 21 quintals. An improved crib, to be constructed locally using woven bamboo and plastered

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[1]Pieter Van Beyma, personal communication, 6 January 1968.

walls with a thatched roof, has been designed at the Jimma agricultural school. Only plaster and a metal chute must be purchased; the rate of crop attrition will be reduced to a maximum of 10 per cent. These cribs have a capacity of 11.3 quintals and cost, including local labor, $6.00 each. It is proposed to replace the old cribs gradually as they deteriorate. Old cribs have a life of about five years and the new ones have been depreciated over six years. The required cribs are to be constructed during September, when work is slack, by hiring labor at the established wage rate ($0.06 per man-hour).

In calculating the number of cribs required it was assumed that the more highly valued crops, sorghum and sesame, should be stored in the new cribs first. Maize can be accommodated in new cribs as space becomes available. Beans are to be stored in the homes since only a small quantity is produced. It is assumed that the marketed proportion of citrus fruits (80 per cent) will be transported away from the area as picking proceeds, 5 per cent of the crop is consumed locally and the remainder is waste.

Subsistence Crop Yields

The budget model has been developed on the assumption that maize, sorghum, and beans will continue to be grown only for subsistence. Grain production has been increased in direct proportion to the rate of population increase; the volume of bean production has been increased at a slightly higher rate in order to improve the supply of protein in the local diet.

Improved seed varieties are introduced at the beginning of the budget model (t=1) only for sesame. After the establishment of improved equipment and the new cultivation techniques, improved varieties of maize, sorghum, and beans are introduced into the system in the sixth year; increasing yields are anticipated thereafter.

Few agronomic experiments have been conducted in remote areas of Ethiopia. Thus, yield assumptions for Agnale are based on best available estimates: a generalized model published by the Stanford Research Institute for determining crop yields on Ethiopian "type 1" (alluvial) soils.[1] This model enables crop yields for

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[1]Carl F. Miller, *et al.*, *System Analysis Methods . . .*, p. 40.

improved varieties to be approximated on the basis of rainfall, temperature, and soil conditions data. Crop yields determined by the SRI model are included in the basic assumptions for the budget model for Agnale shown in Table A.2(b). These data form the basis of estimating maximum yields. Beginning in the initiating year (t=0) with approximations to the actual yields currently being achieved in the area, two levels of production have been assumed from the introduction of new varieties: high-level yields, the calculated maximum being attained in the tenth year; low-level yields, approximately half the maximum being attained in the tenth year. Data for both yield and price assumption for subsistence crops are contained in Table A.2(c).

Cash Crops

Three cash crops are included in the proposed improvements: sesame, lemon, and orange. Sesame, to begin production in the first year of the budget model (t=1), fulfills the need for an immediate cash income to cover additional costs incurred by the acquisition of improved tools and storage cribs. Citrus fruit production begins in the fourth year of the budget model (t=4).

Since sesame was not included in the observations of the initiating year, an arbitrary assumption of yields in the first year (t=1) was made of one-half the calculated maximum attainable yield. In the case of the citrus orchards, the fraction of the maximum attainable yield is determined by the value of the aging function (Φa).

Recent data on citrus orchards maintained under optimal conditions indicate that yield increases can be expected up to almost 40 years after planting and that good yields can be obtained up to an age of 60 years. However, optimal conditions seldom pertain in practice.[1] Two aging functions were used to determine yields of citrus for two production levels. The higher level yields were derived from the generalized aging function in which the orchard attains maximum production more rapidly and becomes more rapidly exhausted than in the case of the equation for optimal conditions, employed to establish the lower level. Data for both yield and price assumptions for cash crops are contained in Table A.2(c).

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[1] *Ibid.*, pp. 198-203.

TABLE A.2 Continued
b. Determination of maximum attainable yields for subsistence and cash crops, budget model (t=0,...,10)

Crop	Variety	Growing season	k_t[a]	k_R[a]	T[a]	T_m[a]	R[a]	R_m[a]	s_m[a]	S_m[a]	ϕ_1[a]	$\phi_2 \cdot \phi_3$[a]	$\phi_4 \cdot \phi_5 \cdot \phi_6$[a]	ϕ_7[a]	ϕ_8[a]	ϕ_9[a] t_o	ϕ_9[a] t_m	ϕ_{10}[a]	Y_m[a]	Y[a]	Maximum yield assumed
			$(°C)^{-2}$	(m./month)$^{-2}$	°C	°C	m./month	m./month	kg/ha.	plants/ha.									q/ha.	q/ha.	q/ha.
Maize	Regular 170	Oct-Mar	.0419	22.6	28.90	26.5	.0283	.20	(20)[b]	33,400	1.0[b]	.7840[d]	.99	1.0	-	-	-	-	58.4	45.33	45.3
		Apr-Aug	.0419	22.6	27.59	26.5	.1520	.20	(20)[b]	33,400	1.0[b]	.9072[d]	.99	1.0	-	-	-	-	58.4	52.45	52.4
Sorghum	NK 320	Oct-Mar	-	-	28.90	25.0	.0282	.0818	11	71,000	1.0[c]	.7351[e]	.90	1.0	-	-	-	-	101.0	67.00	67.0
Beans	Amarillo	Oct-Mar	-	-	28.90	20.0	.0282	.1200	18	56,000	1.0[c]	.3329[f]	.99	1.0	-	-	-	-	54.0	17.80	17.8
		Apr-Aug	-	-	27.59	20.0	.0282	.1200	18	56,000	1.0[c]	.7952[f]	.99	1.0	-	-	-	-	54.0	42.50	42.5
Sesame	Glauca	Nov-Mar	.0250	63.1	29.15	26.0	.0619	.1270	20	134,000	1.0[b]	.5969[d]	1.00	1.0	1.0	-	-	-	18.3	10.45	10.4
Lemon	Eureka	Perennial	.0118	500.0	29.66	28.0	.0917	.1040	-	167	1.0[c]	.6971[d]	1.00	1.0	1.0	3 3	50 22	1.0	750.0	727.17 627.81	254.0 434.9
Orange	W. Navel	Perennial	.0118	591.0	29.66	30.0	.0917	.0929	-	222	1.0[c]	.9999[d]	1.00	1.0	1.0	3 3	38 20	1.0	560.0	558.70 558.70	242.0 414.3

[a]Symbols used in production functions:

k_t--yield deviation rate for temperature variation
k_R--yield deviation rate for rainfall variation
T--average temperature over growing season
T_m--characteristic temperature at which highest yields occur
R--average rainfall rate over growing season
R_m--characteristic rainfall at which highest yields occur
D_m--seeding rate giving maximum yields (s--rate used)
S_m--plant density giving maximum yields (S--rate used)
ϕ_1--seed rate or plant rate function
ϕ_2--temperature dependent term
ϕ_3--rainfall dependent term
ϕ_4--nitrogen response function
ϕ_5--phosphate response function
ϕ_6--potash response function
ϕ_7--soil structure factor
ϕ_8--marketable fraction
ϕ_9--plant aging function (for tree crops)
ϕ_{10}--acidity function (for tree crops)

t_o--last year of growth without fruit (tree crops)
t_m--yield of maximum yield (tree crops)
Y_m--maximum yield ($\phi_1 = \phi_2 = \ldots = \phi_{10} = 1.0$)
Y--calculated maximum yield at Aonale

$b_{\phi_1} = (S/S_m)e^{3[1-(S/S_m)^{1/3}]}$

$c_{\phi_1} = (s/s_m)e^{3[1-(s/s_m)^{1/3}]}$

$d_{\phi_2 \cdot \phi_3} = e^{-k_t(T-T_m)^2} e^{-k_R(R-R_m)^2}$

$e_{\phi_2 \cdot \phi_3} = (2-T/T_m)(T/T_m)(R/R_m)e^{(R_m-R)/R_m}$

$f_{\phi_2 \cdot \phi_3} = (2-T/T_m)(2-R/R_m)(T/T_m)(R/R_m)$

g_{ϕ_9}--aging equation for optimum conditions:

$\phi_{9(t=4,\ldots,10)} = 0.0619(t-3)$;

$\phi_{9(t=11,\ldots,60)} = \dfrac{(t-3)e^{(37.5-t)/34.5}}{35.5}$

h_{ϕ_9}--generalized aging equation:

$$\phi_9 = \frac{(t-3)e^{(t_m-t)/(t_m-t)}}{t_m-t_o}$$

i--combined production function:

$$Y = Y_m \prod_{i=1}^{n} \phi_i$$

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., pp. 119-203.

TABLE A.2 Continued
b. Determination of maximum attainable yields for subsistence and cash crops, budget model (t=0,...,10)

Crop	Variety	Growing season	k_t[a]	k_R[a]	T[a]	T_m[a]	R[a]	R_m[a]	s_m[a]	S_m[a]	ϕ_1[a]	$\phi_2 \cdot \phi_3$[a]	$\phi_4 \cdot \phi_5 \cdot \phi_6$[a]	ϕ_7[a]	ϕ_8[a]	ϕ_9[a] t_o	ϕ_9[a] t_m	ϕ_{10}[a]	Y_m[a]	Y[a]	Maximum yield assumed
			$(°C)^{-2}$	$(m./month)^{-2}$	°C	°C	m./month	m./month	kg/ha.	plants/ha.									q/ha.	q/ha.	q/ha.
Maize	Regular 170	Oct-Mar	.0419	22.6	28.90	26.5	.0283	.20	(20)[b]	33,400	1.0[b]	.7840[d]	.99	1.0	-	-	-	-	58.4	45.33	45.3
		Apr-Aug	.0419	22.6	27.59	26.5	.1520	.20	(20)[b]	33,400	1.0[b]	.9072[d]	.99	1.0	-	-	-	-	58.4	52.45	52.4
Sorghum	NK 320	Oct-Mar	-	-	28.90	25.0	.0282	.0818	11	71,000	1.0[c]	.7351[e]	.90	1.0	-	-	-	-	101.0	67.00	67.0
Beans	Amarillo	Oct-Mar	-	-	28.90	20.0	.0282	.1200	18	56,000	1.0[c]	.3329[f]	.99	1.0	-	-	-	-	54.0	17.80	17.8
		Apr-Aug	-	-	27.59	20.0	.0282	.1200	18	56,000	1.0[c]	.7952[f]	.99	1.0	-	-	-	-	54.0	42.50	42.5
Sesame	Glauca	Nov-Mar	.0250	63.1	29.15	26.0	.0619	.1270	20	134,000	1.0[b]	.5969[d]	1.00	1.0	1.0	-	-	-	18.3	10.45	10.4
Lemon	Eureka	Perennial	.0118	500.0	29.66	28.0	.0917	.1040	-	167	1.0[c]	.8971[d]	1.00	1.0	1.0	3	50	1.0	750.0	727.17	254.0
																3	22			627.81	434.9
Orange	W. Navel	Perennial	.0118	591.0	29.66	30.0	.0917	.0929	-	222	1.0[c]	.9999[d]	1.00	1.0	1.0	3	38	1.0	560.0	558.70	242.0
																3	20			558.70	414.3

[a]Symbols used in production functions:

k_t--yield deviation rate for temperature variation

k_R--yield deviation rate for rainfall variation

T--average temperature over growing season

T_m--characteristic temperature at which highest yields occur

R--average rainfall rate over growing season

R_m--characteristic rainfall at which highest yields occur

D_m--seeding rate giving maximum yields (s--rate used)

S_m--plant density giving maximum yields (S--rate used)

ϕ_1--seed rate or plant rate function

ϕ_2--temperature dependent term

ϕ_3--rainfall dependent term

ϕ_4--nitrogen response function

ϕ_5--phosphate response function

ϕ_6--potash response function

ϕ_7--soil structure factor

ϕ_8--marketable fraction

ϕ_9--plant aging function (for tree crops)

ϕ_{10}--acidity function (for tree crops)

t_o--last year of growth without fruit (tree crops)

t_m--yield of maximum yield (tree crops)

Y_m--maximum yield ($\phi_1=\phi_2=\ldots=\phi_{10}=1.0$)

Y--calculated maximum yield at Agnale

$b_{\phi_1}=(S/S_m)e^{3[1-(S/S_m)^{1/3}]}$

$c_{\phi_1}=(s/s_m)e^{3[1-(s/s_m)^{1/3}]}$

$d_{\phi_2 \cdot \phi_3}=e^{-k_t(T-T_m)^2} e^{-k_R(R-R_m)^2}$

$e_{\phi_2 \cdot \phi_3}=(2-T/T_m)(T/T_m)(R/R_m)e^{(R_m-R)/R_m}$

$f_{\phi_2 \cdot \phi_3}=(2-T/T_m)(2-R/R_m)(T/T_m)(R/R_m)$

g_{ϕ_9}--aging equation for optimum conditions:

$\phi_{9(t=4,\ldots,10)}=0.0619(t-3)$;

$\phi_{9(t=11,\ldots,60)}=\frac{(t-3)e^{(37.5-t)/34.5}}{35.5}$

h_{ϕ_9}--generalized aging equation:

$\phi_9=\frac{(t-3)e^{(t_m-t)/(t_m-t)}}{t_m-t_o}$

i--combined production function:

$Y=Y_m \prod_{i=1}^{n} \phi_i$

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., pp. 119-203.

TABLE A.2 Continued
c. Prices and annual yield assumptions in dry and wet seasons, budget model (t=0,...,10)

Crop	Production level	Price: Crop function: Subsistence	Price: Crop function: Cash	0 Dry	0 Wet	1 Dry	1 Wet	2 Dry	2 Wet	3 Dry	3 Wet	4 Dry	4 Wet	5 Dry	5 Wet	6 Dry	6 Wet	7 Dry	7 Wet	8 Dry	8 Wet	9 Dry	9 Wet	10 Dry	10 Wet
		dollars[a] per quintal		quintals per hectare																					
Maize	H[b]	4.00	-	15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	22.6	26.2	28.3	32.8	34.0	39.3	39.6	45.8	45.3	52.5
	L[c]			15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	15.0	20.0	22.6	26.2	22.6	26.2	22.6	26.2	22.6	26.2	22.6	26.2
Sorghum	H	4.00	-	18.0	-	18.0	-	18.0	-	18.0	-	18.0	-	18.0	-	33.5	-	41.9	-	50.2	-	58.6	-	67.0	-
	L			18.0	-	18.0	-	18.0	-	18.0	-	18.0	-	18.0	-	33.5	-	33.5	-	33.5	-	33.5	-	33.5	-
Beans	H	6.40	-	7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	8.9	21.2	11.1	26.5	13.4	31.8	15.6	37.2	17.8	42.5
	L			7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	7.0	9.0	8.9	21.2	8.9	21.2	8.9	21.2	8.9	21.2	8.9	21.2
Sesame	H	-	16.26	-	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	6.8	-	8.2	-	9.5	-	10.9	-
	L			-	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-	5.4	-
Lemon	H	.50	8.26	-		-		-		-		85.1		161.7		230.0		291.0		345.2		393.0		434.9	
	L			-		-		-		-		35.3		70.5		106.9		142.6		184.9		216.5		254.0	
Orange	H	.50	8.26	-		-		-		-		83.2		158.4		223.9		282.4		331.0		376.5		414.3	
	L			-		-		-		-		34.5		69.1		103.7		138.3		172.9		207.5		242.0	

[a] U.S. dollars.
[b] H = high-level yields.
[c] L = low-level yields.

Labor Utilization

Labor is largely occupied in cultivating subsistence crops. However, the people have shown themselves willing to work for cash wages to a limited extent; the local wage rate appeared to have been established by the missionaries at $0.06 per man-hour. It is proposed to hire workers from the village for all labor involved in the establishment and production of cash crops. Operations are to be under the supervision of the village elders and the surveillance of the local extension agent. Cash wages will also be paid for the spraying operation on subsistence crops. Labor requirements for both establishment and cultivation of cash crops are given in Table A.2(d). Labor requirements for subsistence crops have been included in Table A.1.

Establishment Costs

In the first year of the budget model (t=1) simple irrigation canals and protective levees to hold back flood waters are to be constructed. During this period of establishment improved tools are being introduced to improve labor productivity so that the additional work in the orchards and the sesame crop can be accommodated. Under appropriate supervision, there is time to construct these earthworks during October. The seedlings are to be planted during November; weeding, irrigating, and spraying will follow; toward the end of the dry season the established seedlings will be thinned just prior to the onset of the rains.

The area of citrus to be grown was a major decision which has been made on the basis of labor requirements in the sixth year of the budget model, the first year when additional (hired) labor is also required to spray subsistence crops: the year when the full range of new activities has been introduced. Citrus fruits are harvested in January and February. Calculations of available man-hours on the basis of high level yields suggested that 15.7 hectares was the maximum area that could be grown. Assuming that the people's expectation of leisure would permit half of this area to be grown, an arbitrary division of 5.20 hectares of lemon and 2.60 hectares of orange was adopted.

Basic assumptions for the establishment of citrus orchards are shown in Table A.2(e). Repayment of these expenses is to be accommodated on the basis of a special long term loan, the details of which are discussed below under "Financial Costs."

TABLE A.2 Continued
d. Labor operational requirements for cash crop establishment and cultivation by calendar months, budget model (t=1,...,10)

Crop	Items	October	November	December	January	Feb.	March	April	May	June	July	Aug.	September	Total
Season		Dry							Wet					
Sesame	--operations	clear	cultivate & plant	cultivate & weed	thin & weed	spray	harvest							
	--labor (man-days)	21.25/ha.	3.75/ha.	21.25/ha.	21.25/ha.	5/ha.	3.75/q.							
	--labor (man-hours)	95.0/ha.	22.5/ha.	95.0/ha.	95.0/ha.	40/ha.	30.0/q.							
Lemon	--establishment	canal construction	plant	weed, irrigate, spray			weed, thin, irrigate, spray						canal maintenance	
	--labor (man-hours)	237/ha.[a]	94/ha[b]	(53+242+58)/ha.			(80+5+242+50)/ha.						182	1,252
	--operations	weed, irrigate,[d] spray[e]				harvest	weed, irrigate, spray						maint. & spray	
	--labor (man-hours)	144/ha.	176/ha.	130/ha.		3.0/q.	177/ha.	178/ha.					(182+47)/ha.	1,034
Orange	--establishment		canal construction, plant	weed, irrigate, spray			weed, thin, irrigate, spray						canal maintenance	
	--labor (man-hours)		(392[c]+111)/ha.	(53+284+70)/ha.			(80+12+284+69)/ha.						237/ha.	1,592
	--operations	weed, irrigate, spray			harvest		weed, irrigate, spray						maint. & spray	
	--labor (man-hours)	170/ha.	200/ha.	147/ha.	3.0q.		202/ha.	204/ha.					(237+56)/ha.	1,216

[a] .5 man-hour per meter for 1x100 meters of main canal; 10 man-minutes per meter for 2x100 meter secondary canals; 10 man-minutes per meter for 22.2x41.5 meter tertiary canals: each tertiary canal contains 5 trees.

[b] Planting based on .5 man-hour per plant including construction of basin to tertiary canal (thinning-5 per cent of planting labor).

[c] .5 man-hour per meter for 1x100 meters of main canal; 10 man-minutes per meter for 3x100 meter secondary canals; 10 man-minutes per meter for 45x10.3 meter tertiary canals: each tertiary canal contains 5 trees.

[d] Based on .5 man-hour per 5 plants plus an equal length of time for manually operated pumps plus 3 hours per hectare to wet canals--repeated 12 times per year.

[e] Based on average time of 25 minutes per tree.

TABLE A.2 Continued
e. Citrus orchard establishment costs, budget model (t=1,2,3)

Crop items	Year 1 Number per hectare	Year 1 Total units	Year 1 Price per unit	Year 1 Cost	Year 2 Number per hectare	Year 2 Total units	Year 2 Cost	Year 3 Number per hectare	Year 3 Total units	Year 3 Cost
			dollars[a]	dollars[a]			dollars[a]			dollars[a]
Lemon--5.20 hectares										
Establishment:										
Plants	(187)(1.05)[b]	1,020.5	.40	408.20						
Canal construction (man-hrs.)	237	1,232								
Planting and thinning (man-hrs.)	99	515								
	336	1,747								
Annual operations:										
Weed, irrigate, spray (man-hrs.)	734[c]	3,816			773[c]	4,019		812[c]	4,222	
Canal maintenance (man-hrs.)	182	945			182	945		182	945	
	1,252	6,508	.06	390.48	955	4,964	297.84	994	5,167	310.02
Spray[d] (liters)	538	2,800	.16	448.00	717	3,731	597.00	897	4,663	746.00
Total				1,246.68			894.84			1,056.02
Orange--2.60 hectares										
Establishment:										
Plants	(222)(1.05)[b]	606.05	.40	242.42						
Canal construction (man-hrs.)	392	1,019								
Planting and thinning (man-hrs.)	123	320								
	515	1,339								
Annual operations:										
Weed, irrigate, spray (man-hrs.)	840[c]	2,184			886[c]	2,304		932[c]	2,424	
Canal maintenance	237	615			237	615		237	615	
	1,592	4,138	.06	248.28	1,123	2,919	175.14	1,169	3,039	182.34
Spray[e] (liters)	642	1,668	.16	267.00	858	2,231	357.00	1,072	2,788	446.00
Total				757.70			532.14			628.34
Total for citrus				2,005.38			1,426.98			1,684.36
Equipment	Total cost	Depreciation[f]								
6 Knapsack sprayer	192	48								
2 Hand pumps[g]	100	20								
48 Hand tools	24	1.88								
	316	69.88		385.88			69.88			69.88
Total				2,390.26			1,496.86			1,754.24
Cumulated total				2,390.26			4,054.44			6,092.49
Cumulated total at 7% interest (Establishment cost)				2,557.58			4,338.25			6,518.97
t=4 (7% interest added)										6,975.30
t=5 (7% interest added)										7,463.57
t=6 (begin repayment)(7% interest added)										7,986.02

[a]U.S. dollars. [b]Five per cent margin to allow for replacing dead seedlings.

[c]Increase due to 1/2 rate spray program in t=1 building up to full rate in t=4.

[d]Full rate 1,014 liters, 50 per cent malathion emulsion ($0.16 per liter); applied as a 20 per cent solution (approximately 4.5 liters/tree, three times per season).

[e]Full rate 1,210 liters, 50 per cent malathion emulsion; applied as a 20 per cent solution.

[f]Depreciation included in order to provide funds for replacement of rapidly depreciating equipment.

[g]Chain pumps (see Kline, *et al.*, Pt. II, p. 282)--one pump in reserve.

The market price for citrus fruits has been taken as that ruling in Addis Abeba in 1967-68[1] since the bulk of the crop will be transported to this market. Transport charges by truck were estimated at $0.932 per quintal.[2]

Crop Protection

The spraying program is uncomplicated. Citrus trees are to be sprayed with a 20 per cent solution of malathion emulsion, three times per season. In the establishment period spray applications are considerably reduced. Spray rates are set out in Table A.2(e).

Cereal crops are to be sprayed with a 0.2 per cent solution of DDT[3] (2 liters of liquid DDT per hectare). The program should begin when improved varieties of seed are introduced (t=6 for maize, sorghum and beans, t=1 for sesame).

Budgets

Outputs and Inputs

The basic assumptions necessary to prepare the budget are contained in Table A.2. From these data selected budgeted accounts of outputs and inputs over the ten year period are presented in Tables A.3 and A.4. Only the accounts for high-level yields are presented in full. Subsequently, Tables A.5 and A.6 contain the output and input data in summary.

In the Agnale economy, availability of hand labor is the limiting factor to expansion. In order to facilitate an increase in the output of the system and the introduction additional crops, a combination of technological improvements has been employed: improved hand tools to raise labor productivity, improved varieties and improved storage facilities which together serve to reduce the area required for subsistence crops.

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[1] Ibid., p. 115.

[2] Estimated on the basis of data contained in Zerom, op. cit., p. 20.

[3] In view of recent discoveries concerning the use of DDT, a more appropriate insecticide may be used.

TABLE A.3 Agnale: Annual income accounts of budget model (t=0,...,10)--high-level yields, years 4-10

Year	Crop	Area	Total area cropped	Waste	Yield: Dry season	Yield: Wet season	Production	Non-cash product	Cash product	Gross income[a]
		hectares	hectares	per cent	q/ha.	q/ha.	quintals	dollars[b]	dollars[b]	dollars[b]
0	Maize	38.40	76.80	40.0	15.0	20.0	806.40	3,225.60	-	3,225.60
	Sorghum	33.57	33.57	50.0	18.0	-	302.40	1,209.60	-	1,209.60
	Bean	1.00	2.00	40.0	7.0	9.0	9.60	61.44	-	61.44
	Total	73.97	112.37					4,496.64	-	4,496.64
1	Maize	37.93	75.86	38.7	15.0	20.0	813.73	3,254.92	-	3,254.92
	Sorghum	26.65	26.65	36.4	18.0	-	305.03	1,220.12	-	1,220.12
	Bean	.87	1.74	33.0	7.0	9.0	9.33	59.71	-	59.71
	Sesame	.90	.90	10.0	5.4	-	4.37	-	71.01	71.01
	Total	66.35	105.15					4,434.75	71.01	4,605.76
2	Maize	37.71	75.42	37.7	15.0	20.0	822.50	3,290.00	-	3,290.00
	Sorghum	18.87	18.87	10.0	18.0	-	305.96	1,222.76	-	1,222.76
	Bean	.78	1.56	26.0	7.0	9.0	9.24	59.14	-	59.14
	Sesame	1.60	1.60	10.0	5.4	-	7.76	-	126.12	126.12
	Total	58.96	97.45					4,571.90	126.12	4,698.02
3	Maize	32.77	65.54	27.7	15.0	20.0	829.42	3,317.68	-	3,317.68
	Sorghum	19.11	19.11	10.0	18.0	-	309.48	1,238.32	-	1,238.32
	Bean	.69	1.38	18.0	7.0	9.0	9.05	57.92	-	57.92
	Sesame	2.63	2.63	10.0	5.4	-	12.78	-	207.84	207.84
	Total	55.20	88.66					4,613.92	207.84	4,821.76
4	Maize	26.49	52.98	10.0	15.0	20.0	834.44	3,337.76	-	3,337.76
	Sorghum	19.30	19.38	10.0	18.0	-	312.66	1,250.64	-	1,250.64
	Bean	.62	1.24	10.0	7.0	9.0	8.93	57.15	-	57.15
	Sesame	3.66	3.66	10.0	5.4	-	17.81	-	289.55	289.55
	Lemon	5.20	5.20	15.0	85.1		376.14	33.19	2,558.65	2,591.84
	Orange	2.60	2.60	15.0	83.2		183.87	16.22	1,250.76	1,266.98
	Total	57.87	84.98					4,694.96	4,098.96	8,793.93[c]
5	Maize	26.76	53.52	10.0	15.0	20.0	842.98	3,371.92	-	3,371.92
	Sorghum	19.50	19.50	10.0	18.0	-	315.90	1,263.60	-	1,263.60
	Bean	.63	1.26	10.0	7.0	9.0	9.08	58.11	-	58.11
	Sesame	3.73	3.73	10.0	5.4	-	18.12	-	294.56	294.56
	Lemon	5.20	5.20	15.0	161.7		714.71	63.06	4,861.74	4,924.80
	Orange	2.60	2.60	15.0	158.4		350.06	30.89	2,381.26	2,412.15
	Total	58.42	85.81					4,787.58	7,537.56	12,325.14
6	Maize	19.23	38.46	10.0	22.6	26.2	844.48	3,377.92	-	3,377.92
	Sorghum	10.55	10.55	10.0	33.5	-	317.75	1,271.00	-	1,271.00
	Bean	.31	.62	10.0	8.9	21.2	8.23	52.68	-	52.67
	Sesame	4.34	4.34	10.0	5.4	-	21.11	-	343.30	343.30
	Lemon	5.20	5.20	15.0	230.0		1,016.60	89.70	6,915.27	7,004.97
	Orange	2.60	2.60	15.0	223.9		494.82	43.66	3,365.93	3,409.59
	Total	42.23	61.77					4,834.96	10,624.50	15,459.46
7	Maize	15.52	31.04	10.0	28.3	32.8	852.80	3,411.20	-	3,411.20
	Sorghum	8.49	8.49	10.0	41.9	-	320.88	1,283.52	-	1,283.52
	Bean	.27	.54	10.0	11.1	26.5	9.06	57.98	-	57.98
	Sesame	4.70	4.70	10.0	6.8	-	21.06	-	467.56	467.56
	Lemon	5.20	5.20	15.0	291.0		1,286.22	113.49	8,749.32	8,862.81
	Orange	2.60	2.60	15.0	282.4		624.10	55.07	4,245.38	4,300.45
	Total	36.78	52.70					4,921.26	13,462.26	18,383.52
8	Maize	13.07	26.14	10.0	34.0	39.3	861.12	3,444.48	-	3,444.48
	Sorghum	7.19	7.19	10.0	50.2	-	324.01	1,296.04	-	1,296.04
	Bean	.25	.50	10.0	13.4	31.8	9.92	63.49	-	63.49
	Sesame	4.94	4.94	10.0	8.2	-	21.01	-	592.25	592.25
	Lemon	5.20	5.20	15.0	345.2		1,525.78	134.63	10,378.92	10,513.55
	Orange	2.60	2.60	15.0	331.0		731.51	64.55	4,975.99	5,040.54
	Total	33.26	46.37					5,003.19	15,947.16	20,950.34
9	Maize	11.32	22.64	10.0	39.6	45.8	869.44	3,477.76	-	3,477.76
	Sorghum	6.21	6.21	10.0	58.6	-	327.14	1,308.56	-	1,308.56
	Bean	.23	.46	10.0	15.6	37.2	10.78	69.00	-	69.00
	Sesame	5.72	5.72	10.0	9.5	-	23.58	-	795.40	795.40
	Lemon	5.20	5.20	15.0	393.0		1,737.06	153.27	11,816.10	11,969.37
	Orange	2.60	2.60	15.0	376.5		832.06	73.42	5,660.00	5,733.42
	Total	31.28	42.83					5,082.01	18,271.50	23,353.50
10	Maize	10.04	20.08	10.0	45.3	52.4	881.92	3,527.68	-	3,527.68
	Sorghum	5.52	5.52	10.0	67.0	-	331.84	1,327.36	-	1,327.36
	Bean	.22	.44	10.0	17.8	42.5	11.72	75.01	-	75.01
	Sesame	6.74	6.74	10.0	10.9	-	27.08	-	1,075.54	1,075.54
	Lemon	5.20	5.20	15.0	434.9		1,922.26	169.61	13,075.88	13,245.49
	Orange	2.60	2.60	15.0	414.3		915.60	80.79	6,668.25	6,309.04
	Total	30.32	40.57					5,180.45	20,379.67	25,560.12

[a] Total of non-cash and cash incomes.

[b] U.S. dollars.

[c] Small errors in addition are due to calculated values being rounded to 2 decimal places.

TABLE A.4 Agnale: Annual input accounts, budget model (t=0,...,10)--high-level yields, years 4-10

Year	Crop	Labor: Non-cash	Labor: Cash	Seed: Non-cash	Seed: Cash	Spray: Cash	Packing: Cash	Depreciation: Non-cash	Depreciation: Cash	Total inputs: Non-cash	Total inputs: Cash	Total inputs: Total
		-----	-----	-----	-----	dollars[a]	-----	-----	-----	-----	-----	-----
0	Maize	1,469.28	-	153.60	-	-	-	45.72	-	1,668.60	-	1,668.60
	Sorghum	1,047.60	-	47.00	-	-	-	19.98	-	1,114.58	-	1,114.58
	Beans	103.20	-	41.60	-	-	-	1.19	-	145.99	-	145.99
	Total	2,620.08	-	242.20	-	-	-	66.89	-	2,929.17	-	2,929.17
1	Maize	1,451.22	-	151.72	-	-	-	38.11	12.84	1,641.05	12.84	1,653.89
	Sorghum	831.66	-	37.31	-	-	-	13.39	4.51	882.36	4.51	886.87
	Beans	90.23	-	36.20	-	-	-	.87	.30	127.30	.30	127.60
	Sesame	-	27.50	-	3.01	.77	.50	.45	.15	.45	31.93	32.38
	Total	2,373.11	27.50	225.23	3.01	.77	.50	52.82	17.80	2,651.16	49.58	2,700.74
2	Maize	1,372.86	-	150.84	-	-	-	29.92	24.50	1,553.62	24.50	1,578.12
	Sorghum	574.80	-	26.42	-	-	-	7.42	6.08	608.64	6.08	614.72
	Beans	76.32	-	32.45	-	-	-	.62	.51	109.39	.51	109.90
	Sesame	-	46.83	-	5.35	1.37	.80	.64	.51	.64	54.87	55.50
	Total	2,023.98	46.83	209.71	5.35	1.37	.80	38.60	31.60	2,272.29	85.95	2,358.24
3	Maize	1,134.82	-	131.08	-	-	-	18.13	40.21	1,284.03	40.21	1,324.24
	Sorghum	528.30	-	26.75	-	-	-	5.29	11.73	560.34	11.73	572.07
	Beans	63.48	-	28.70	-	-	-	.38	.85	92.56	.85	93.41
	Sesame	-	73.70	-	8.82	2.26	1.30	.73	1.61	.73	87.69	88.42
	Total	1,726.60	73.70	186.53	8.82	2.26	1.30	24.53	54.40	1,937.66	140.48	2,078.14
					Years 4-10: High-level yields							
4	Maize	868.97	-	105.96	-	-	-	7.08	100.96	982.01	100.96	1,082.97
	Sorghum	499.14	-	27.02	-	-	-	2.58	36.78	528.74	36.78	565.52
	Beans	53.76	-	25.79	-	-	-	.17	2.36	79.72	2.36	82.07
	Sesame	-	98.49	-	12.29	3.16	1.80	.48	6.98	.48	122.72	123.20
	Lemon	-	408.06	-	-	843.29	27.35	-	-	-	1,278.70	1,278.70
	Orange	-	222.96	-	-	503.19	13.37	-	-	-	739.52	739.52
	Total	1,421.87	729.51	158.77	12.29	1,349.64	42.52	10.30	147.08	1,590.95	2,281.04	3,871.99
5	Maize	833.34	-	107.04	-	-	-	6.79	103.03	947.17	103.03	1,050.20
	Sorghum	472.38	-	27.30	-	-	-	2.47	37.54	502.15	37.54	539.69
	Beans	51.24	-	26.21	-	-	-	.16	2.43	77.61	2.43	80.04
	Sesame	-	94.38	-	12.50	3.21	1.90	.47	7.18	.47	119.17	119.64
	Lemon	-	479.52	-	-	843.29	51.97	-	-	-	1,374.78	1,374.78
	Orange	-	258.06	-	-	503.19	25.46	-	-	-	786.71	786.71
	Total	1,356.96	831.96	160.55	12.50	1,349.69	79.33	9.89	150.18	1,527.40	2,423.66	3,951.06
6	Maize	616.30	37.57	-	52.07	33.08	-	6.65	137.67	622.97	260.39	883.34
	Sorghum	290.83	10.31	-	7.86	9.07	-	1.81	37.78	292.64	65.02	357.66
	Beans	35.82	.60	-	.98	.53	-	.11	2.19	35.93	4.30	40.23
	Sesame	-	105.31	-	14.57	3.74	2.20	.74	15.54	.74	141.36	142.10
	Lemon	-	543.48	-	-	843.29	73.93	-	354.93	-	1,815.63	1,815.63
	Orange	-	288.78	-	-	503.19	35.98	-	177.47	-	1,005.42	1,005.42
	Total	942.95	986.05	-	75.48	1,392.90	112.11	9.31	725.58	952.26	3,292.12	4,244.38
7	Maize	537.74	29.74	-	42.03	26.70	-	6.17	134.14	543.91	232.61	776.52
	Sorghum	258.41	8.14	-	6.32	7.30	-	1.69	36.69	260.10	58.45	318.55
	Beans	37.71	.52	-	.85	.46	-	.10	2.33	37.81	4.16	41.97
	Sesame	-	125.17	-	15.76	4.04	2.90	.94	20.32	.94	168.19	169.13
	Lemon	-	600.59	-	-	843.29	93.53	-	354.93	-	1,892.34	1,892.34
	Orange	-	316.08	-	-	503.19	45.38	-	177.47	-	1,042.12	1,042.12
	Total	833.86	1,080.24	-	64.96	1,384.98	141.81	8.90	725.88	842.76	3,397.87	4,240.63
8	Maize	486.08	24.47	-	35.40	22.48	-	5.68	131.81	491.76	214.16	705.92
	Sorghum	239.15	6.73	-	5.35	6.18	-	1.56	36.21	240.71	54.47	295.18
	Beans	39.73	.46	-	.79	.44	-	.11	2.54	39.84	4.23	44.07
	Sesame	-	143.92	-	16.55	4.24	3.70	1.70	24.92	1.07	193.33	194.40
	Lemon	-	651.49	-	-	843.29	110.95	-	354.93	-	1,960.66	1,960.66
	Orange	-	338.88	-	-	503.19	53.20	-	177.47	-	1,072.74	1,072.74
	Total	764.96	1,165.95	-	58.09	1,379.82	167.85	8.42	727.88	773.38	3,499.59	4,272.97
9	Maize	447.56	22.24	-	30.65	19.47	-	5.48	127.83	453.04	200.19	653.23
	Sorghum	224.30	6.10	-	4.62	5.34	-	1.50	35.06	225.80	51.12	276.92
	Beans	41.49	.45	-	.73	.40	-	.12	2.60	41.61	4.18	45.79
	Sesame	-	180.22	-	19.19	4.92	4.90	1.38	32.29	1.38	241.52	242.90
	Lemon	-	696.06	-	-	843.29	126.31	-	354.93	-	2,020.59	2,020.59
	Orange	-	360.24	-	-	503.19	60.51	-	177.47	-	1,101.41	1,101.41
	Total	713.35	1,265.31	-	55.19	1,376.61	191.72	8.48	730.18	721.83	3,619.01	4,340.84
10	Maize	424.57	19.25	-	27.19	17.27	-	5.20	121.80	429.77	185.51	615.28
	Sorghum	214.64	5.26	-	4.10	4.74	-	1.43	33.42	216.07	47.52	263.59
	Beans	44.64	.42	-	.69	.38	-	.11	2.68	44.75	4.17	48.92
	Sesame	-	229.39	-	22.62	5.80	6.70	1.74	40.88	1.74	305.39	307.13
	Lemon	-	736.32	-	-	843.29	139.78	-	354.93	-	2,074.32	2,074.32
	Orange	-	382.68	-	-	503.19	66.58	-	177.47	-	1,129.92	1,129.92
	Total	683.85	1,373.32	-	54.60	1,374.67	213.06	8.48	731.18	692.33	3,746.83	4,439.16

[a]U.S. dollars.

TABLE A.5 Agnale: Annual crop areas, waste, and summary of annual total production, budget model (t=0,...,10)

Crop	Number of seasons	Item	Production level	Units	0	1	2	3	4	5	6	7	8	9	10
					Crop areas, waste and summary and total production at indicated year										
Maize	2	**Area**	H	hectares	38.40	37.93	37.71	32.77	26.49	26.76	19.23	15.52	13.07	11.32	10.04
			L	hectares					26.49	26.76	19.23	19.42	19.61	19.80	20.09
		Waste		per cent	40.0	38.7	37.7	27.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Total Production		quintals	806.40	813.73	822.50	829.42	834.44	842.98	844.48	852.80	861.12	869.44	881.92
Sorghum	1	**Area**	H	hectares	33.57	26.65	18.71	19.11	19.30	19.50	10.55	8.49	7.19	6.21	5.51
			L	hectares					19.30	19.50	10.55	10.65	10.75	10.85	11.02
		Waste		per cent	50.0	36.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Total Production		quintals	302.40	335.03	305.96	309.48	312.66	315.90	317.75	320.88	324.01	327.14	331.84
Bean	2	**Area**	H	hectares	1.0	.87	.78	.69	.62	.63	.31	.27	.25	.23	.22
			L	hectares					.62	.63	.31	.34	.37	.40	.44
		Waste		per cent	40.0	33.0	26.0	18.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Total Production		quintals	9.60	9.33	9.24	9.05	8.93	9.08	8.23	9.06	9.92	10.78	11.72
Sesame	1	**Area**		hectares	-	.90	1.60	2.63	3.66	3.73	4.34	4.70	4.94	5.72	6.74
		Waste		per cent	-	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Total Production	H	quintals	-	4.37	7.76	12.78	17.81	18.12	21.11	28.76	36.42	48.92	66.15
			L	quintals					17.81	18.12	21.11	22.84	23.99	27.81	32.77
Lemon	1	**Area**		hectares	-	-	-	-	5.20	5.20	5.20	5.20	5.20	5.20	5.20
		Waste		per cent	-	-	-	-	15.0	15.0	15.0	15.0	15.0	15.0	15.0
		Total Production	H	quintals	-	-	-	-	376.14	714.71	1,016.60	1,286.22	1,525.78	1,737.06	1,922.26
			L	quintals	-	-	-	-	156.03	311.61	472.50	630.29	817.26	956.93	1,122.68
Orange	1	**Area**		hectares	-	-	-	-	2.60	2.60	2.60	2.60	2.60	2.60	2.60
		Waste		per cent	-	-	-	-	15.0	15.0	15.0	15.0	15.0	15.0	15.0
		Total Production	H	quintals	-	-	-	-	183.87	350.06	434.82	624.10	731.51	832.06	915.60
			L	quintals	-	-	-	-	76.24	152.71	229.18	305.64	382.11	458.58	534.82
All Crops		Seasonal total for food crops	H	hectares	112.37	104.25	95.85	86.03	73.52	74.28	49.63	40.07	33.83	29.31	26.03
			L	hectares					73.52	74.28	49.63	50.17	50.71	51.25	52.08
		Seasonal total for cash crops	-	hectares	-	.90	1.60	2.63	11.46	11.53	12.14	12.50	12.74	13.52	14.54
		Total seasonal area	H	hectares	112.37	105.15	97.29	88.66	84.98	85.81	61.77	52.57	46.57	42.83	40.57
			L	hectares					84.98	85.81	61.77	62.67	63.45	64.77	66.62
		Total area cropped	H	hectares	72.97	66.35	58.80	55.20	57.87	58.42	42.23	36.78	33.25	31.28	30.31
			L	hectares					57.87	58.42	42.23	42.91	43.47	44.57	46.09

TABLE A.6 Agnale: Summary of annual gross incomes, budget model (t=0,...,10)

Income	Crops	0	1	2	3	4	5	6	7	8	9	10
		Annual gross incomes at indicated year										
		----------dollars[a]----------										
						Years 4-10: High-level yields						
Non-cash	Subsistence	4,496.64	4,534.75	4,571.90	4,613.92	4,645.55	4,693.63	4,701.60	4,752.70	4,804.01	4,855.32	4,930.05
Non-cash	Cash	-	-	-	-	49.41	93.95	133.36	168.56	199.18	226.69	250.40
Total non-cash		4,496.64	4,534.71	4,571.90	4,613.92	4,694.97	4,787.58	4,834.96	4,921.26	5,003.18	5,082.00	5,180.45
Cash	Cash	-	71.01	126.12	207.84	4,098.97	7,537.56	10,624.50	13,462.26	15,947.16	18,271.50	20,379.67
Total income		4,496.64	4,605.76	4,698.02	4,821.76	8,793.93	12,325.14	15,459.46	18,383.52	20,950.34	23,353.50	25,560.12
						Years 4-10: Low-level yields						
Non-cash	Subsistence					4,645.55	4,693.63	4,701.60	4,752.66	4,804.01	4,855.32	4,930.05
Non-cash	Cash					20.50	40.97	61.91	92.58	105.83	124.89	146.25
Total non-cash						4,666.05	4,734.60	4,763.51	4,845.24	4,909.84	4,980.21	5,076.30
Cash	Cash					1,869.54	3,453.03	5,116.34	6,737.86	8,548.54	10,080.90	11,807.74
Total income						6,535.59	8,187.63	9,879.85	11,573.10	13,458.38	15,061.11	16,884.04

[a]U.S. dollars.

From observation (t=0) labor is mainly occupied in growing subsistence crops. No cash wages are received for this occupation; labor input has been charged and classified as a non-cash input for subsistence production. Work on cash crops is to be supervised by the local extension worker in cooperation with the village elders. Labor is to be paid cash for this work; this cost is classified as a cash input at the same price of $0.06 per man-hour.

The distribution and availability of labor is vital to this system's operation, the use, distribution and total availability of labor has been estimated in Table A.7.

Depreciation has been charged for all equipment and for the citrus orchards. Equipment and tools used in the initiating year have been depreciated and charged as non-cash inputs since the user seldom pays cash for their replacement. These items consisted of old storage cribs, old tools to be replaced (the challa), and other sets of old tools. The equipment and tools depreciated and charged as cash inputs consist of improved cribs, improved tools, and spray equipment used on cereal crops. All depreciation rates for equipment and tools are recorded in the footnotes to Table A.2(a). Depreciation costs other than those for citrus crops have been distributed among the cereal crops, weighted in proportion to area.

Without more precise experimental knowledge it is uncertain how long the orchards will continue to bear fruit. However, the long term financial agreement is to repay the loan raised for establishment costs in the twentieth year of operation (t=20). Repayment installments are to be forestalled until the sixth year and no cash charges are to be made for orchard depreciation until the sixth year. Therefore, orchard depreciation has been charged at one-fifteenth of the total establishment costs and accrual of interest commenced in the sixth year.

Depreciation charges which are cash inputs serve to establish a cash fund. Since it is intended to purchase new equipment and tools on loans from the credit institutions, the cash funds from the depreciation charges have been applied to repayment of the financial charges.

Other required inputs, seeds and sprays, are contained in Table A.8. Necessary packing material and labor was estimated at $0.10 per quintal[1] for putting

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[1]Grain sacks are standardized to contain one quintal.

TABLE A.7 Agnale: Estimated distribution of labor use and availability by calendar months, budget model (t=0,...,10)

Year	Labor utilization	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
		man-hours												
0	Food crops	4,080	720	6,480	6,240	5,968	5,040	5,460	2,880	4,080	960	1,760	-	43,688
	New cribs[a]	-	-	-	-	-	-	-	-	-	-	-	640	640
	Total used	4,080	720	6,480	6,240	5,968	5,040	5,460	2,880	4,080	960	1,760	640	44,328
	Total available	6,480	6,240	6,480	6,480	7,408	6,480	8,460	6,480	6,240	6,840	7,768	6,240	81,596
1	Food crops	4,030	711	5,610	5,317	5,220	4,467	4,730	2,817	4,002	948	1,700	-	39,552
	Cash crops	85	21	85	85	36	146	-	-	-	-	-	-	458
	Establishment	1,232	3,043	676	1,011	369	1,248	1,315	-	-	-	-	1,752	10,646
	New cribs	-	-	-	-	-	-	-	-	-	-	-	480	480
	Total used	5,347	3,775	6,371	6,413	5,625	5,861	6,045	2,817	4,002	948	1,700	2,232	51,136
	Total available	6,550	6,308	6,550	6,550	7,488	6,550	8,552	6,550	6,308	6,914	7,852	6,308	82,478
2	Food crops	4,007	635	4,409	3,877	4,423	3,841	3,889	2,496	3,554	943	1,659	-	33,733
	Cash crops	151	32	137	137	64	259	-	-	-	-	-	-	780
	Establishment	1,064	1,310	1,058	-	-	1,315	1,318	-	-	-	-	1,818	7,883
	New cribs	-	-	-	-	-	-	-	-	-	-	-	840	840
	Total used	5,222	1,977	5,604	4,014	4,487	5,415	5,207	2,496	3,554	943	1,659	2,658	43,236
	Total available	6,622	6,376	6,622	6,622	7,570	6,622	8,645	6,622	6,376	6,989	7,938	6,376	83,380
3	Food crops	3,482	492	3,961	3,269	3,740	3,250	3,627	1,935	2,754	820	1,447	-	28,777
	Cash crops	250	47	200	200	106	425	-	-	-	-	-	-	1,228
	Establishment	1,139	1,370	1,058	-	-	1,376	1,378	-	-	-	-	1,885	8,206
	New bins	-	-	-	-	-	-	-	-	-	-	-	840	840
	Total used	4,871	1,909	5,219	3,469	3,846	5,051	5,005	1,935	2,754	820	1,447	2,725	39,051
	Total available	6,694	6,446	6,696	6,696	7,652	6,696	8,739	6,696	6,446	7,066	8,024	6,446	84,297
	Years 4-10: High-level yields													
4	Food crops	2,814	348	3,504	2,663	3,158	2,718	3,299	1,380	1,959	662	1,193	-	23,698
	Cash crops	1,539	1,497	1,304	1,237	1,137	2,039	1,456	-	-	-	-	1,950	12,159
	New bins	-	-	-	-	-	-	-	-	-	-	-	40	40
	Total used	4,353	1,845	4,808	3,900	4,295	4,757	4,755	1,380	1,959	662	1,193	1,990	35,897
	Total available	6,767	6,516	6,767	6,767	7,736	6,767	8,834	6,767	6,516	7,143	8,112	6,516	85,208
5	Food crops	2,843	305	3,387	2,337	3,021	2,605	3,309	1,211	1,721	669	1,208	-	22,616
	Cash crops	1,546	1,491	1,263	2,086	2,026	2,048	1,456	-	-	-	-	1,950	13,866
	New bins	-	-	-	-	-	-	-	-	-	-	-	80	80
	Total used	4,389	1,796	4,650	4,423	5,047	4,653	4,765	1,211	1,721	669	1,208	2,030	36,562
	Total available	6,840	6,587	6,840	6,840	7,820	6,840	8,931	6,840	6,587	7,220	8,220	6,587	86,152
6	Food crops	2,043	180	2,127	1,380	2,369	1,617	2,931	698	1,159	830	1,190	-	16,524
	Cash crops	1,603	1,483	1,267	2,877	2,841	2,149	1,456	-	-	-	-	1,950	15,626
	New bins	-	-	-	-	-	-	-	-	-	-	-	680	680
	Total used	3,646	1,663	3,394	4,257	5,210	3,766	4,387	698	1,159	830	1,190	2,630	32,830
	Total available	6,915	6,659	6,915	6,915	7,905	6,915	9,028	6,915	6,659	7,299	8,290	6,659	87,074
7	Food crops	1,648	146	1,708	1,112	2,314	1,304	2,773	566	935	806	1,226	-	14,538
	Cash crops	1,683	1,493	1,302	3,616	3,578	2,286	1,456	-	-	-	-	1,950	17,364
	New bins	-	-	-	-	-	-	-	-	-	-	-	520	520
	Total used	3,331	1,639	3,010	4,728	5,892	3,590	4,229	566	935	806	1,226	2,470	32,422
	Total available	6,990	6,731	6,990	6,990	7,992	6,992	9,126	6,990	6,731	7,379	8,380	6,731	88,022

8	Food crops	1,383	122	1,436	939	2,307	1,095	2,666	477	785	785	1,282	-	13,277
	Cash crops	1,660	1,490	1,290	4,218	4,183	2,658	1,456	-	-	-	-	1,950	18,905
	New bins	-	-	-	-	-	-	-	-	-	-	-	880	880
	Total used	3,043	1,612	2,726	5,157	6,490	3,753	4,122	477	785	785	1,282	2,830	33,062
	Total available	7,067	6,805	7,067	7,067	8,079	7,067	9,226	7,067	6,805	7,459	8,471	6,805	88,985
9	Food crops	1,199	106	1,249	823	2,271	949	2,602	416	688	785	1,281	-	12,369
	Cash crops	1,901	1,517	1,409	4,888	4,833	2,655	1,456	-	-	-	-	1,950	20,609
	New bins	-	-	-	-	-	-	-	-	-	-	-	840	840
	Total used	3,100	1,623	2,658	5,711	7,104	3,604	4,058	416	688	785	1,281	2,790	33,818
	Total available	7,144	6,879	7,144	7,144	8,167	7,144	9,327	7,144	6,879	7,541	8,564	6,879	89,956
10	Food crops	1,066	94	1,112	735	2,297	844	2,575	371	608	781	1,330	-	11,813
	Cash crops	2,099	1,547	1,511	5,489	5,422	2,992	1,463	-	-	-	-	1,950	22,473
	New bins	-	-	-	-	-	-	-	-	-	-	-	80	80
	Total used	3,165	1,641	2,623	6,224	7,719	3,836	4,038	371	608	781	1,330	2,030	34,366
	Total available	7,221	6,954	7,221	7,221	8,256	7,221	9,428	7,221	6,954	7,623	8,657	6,954	90,931
		Years 4-10: Low-level yields												
4	Food crops	2,814	348	3,504	2,663	3,158	2,718	3,299	1,380	1,959	662	1,193	-	23,698
	Cash crops	1,539	1,497	1,304	661	560	2,039	1,456	-	-	-	-	1,950	11,006
	New bins	-	-	-	-	-	-	-	-	-	-	-	40	40
	Total used	4,353	1,845	4,808	3,324	3,718	4,757	4,755	1,380	1,959	662	1,193	1,990	34,844
5	Food crops	2,843	305	3,387	2,337	3,021	2,605	3,309	1,211	1,721	669	1,208	-	22,616
	Cash crops	1,546	1,491	1,263	1,026	969	2,048	1,456	-	-	-	-	1,950	11,749
	New bins	-	-	-	-	-	-	-	-	-	-	-	80	80
	Total used	4,389	1,796	4,650	3,363	3,990	4,653	4,765	1,211	1,721	669	1,208	2,030	34,445
6	Food crops	2,043	180	2,127	1,380	2,369	1,617	2,931	698	1,159	830	1,190	-	16,524
	Cash crops	1,603	1,483	1,267	1,444	1,416	2,149	1,456	-	-	-	-	1,950	12,768
	New bins	-	-	-	-	-	-	-	-	-	-	-	680	680
	Total used	3,646	1,663	3,394	2,824	3,785	3,766	4,387	698	1,159	830	1,190	2,630	29,972
7	Food crops	2,063	182	2,145	1,398	2,419	1,633	2,963	709	1,172	838	1,227	-	16,749
	Cash crops	1,637	1,487	1,279	1,873	1,841	2,207	1,456	-	-	-	-	1,950	13,730
	New bins	-	-	-	-	-	-	-	-	-	-	-	520	520
	Total used	3,700	1,669	3,424	3,271	4,260	3,840	4,419	709	1,172	838	1,227	2,470	30,999
8	Food crops	2,084	184	2,160	1,410	2,465	1,649	2,995	718	1,185	844	1,262	-	16,956
	Cash crops	1,659	1,488	1,291	2,347	2,320	2,244	1,456	-	-	-	-	1,950	14,755
	New bins	-	-	-	-	-	-	-	-	-	-	-	880	880
	Total used	3,743	1,672	3,451	3,757	4,785	3,893	4,451	718	1,185	844	1,262	2,830	32,591
9	Food crops	2,104	186	2,185	1,435	2,502	1,665	3,021	729	1,198	851	1,286	-	17,162
	Cash crops	1,735	1,498	1,326	2,768	2,730	2,373	1,456	-	-	-	-	1,950	15,836
	New bins	-	-	-	-	-	-	-	-	-	-	-	840	840
	Total used	3,839	1,684	3,511	4,203	5,232	4,038	4,477	729	1,198	851	1,286	2,790	33,838
10	Food bins	2,135	188	2,223	1,471	2,562	1,689	3,062	743	1,218	861	1,330	-	17,482
	Cash crops	1,831	1,509	1,375	3,242	3,195	2,538	1,456	-	-	-	-	1,950	17,096
	New bins	-	-	-	-	-	-	-	-	-	-	-	80	80
	Total used	3,966	1,697	3,598	4,713	5,757	4,227	4,518	743	1,218	861	1,330	2,030	34,658

[a]Estimated time for crib construction: 40 man-hours per crib.

TABLE A.8 Agnale: Inputs of seeds and sprays, budget model (t=0,...,10)

Item	Units \ Year	Crop seeds at indicated year				Units \ Year	Crop sprays at indicated year					
		Maize	Sorghum	Beans	Sesame		Maize	Sorghum	Beans	Sesame	Lemon	Orange
		0-5	0-5	0-5	1-10		6-10	6-10	6-10	1-10	1-3	1-3
Price	$/q.[a]	10.00[b]	10.00[b]	16.00[b]	16.77[c]	$/l.[a]	.43	.43	.43	.43	[e]	[e]
Rate	q/ha.	.20	.14	1.30	.20	l/ha.	2.00[d]	2.00[d]	2.00[d]	2.00[d]	-	-
	Units \ Year	6-10	6-10	6-10							4-10	4-10
Price	$/q.[a]	6.77[c]	6.77[c]	8.77[c]	-	$/l.[a]	-	-	-	-	.16	.16
Rate	q/ha.	.20	.11	.18	-	l/ha.	-	-	-	-	1,014[f]	1,210[f]

[a] U.S. dollars.

[b] Local variety purchased during period of scarcity immediately prior to planting.

[c] Improved variety.

[d] Liquid DDT; applied as a 0.2 per cent solution in water.

[e] See establishment costs: Table A.2(e).

[f] Fifty per cent malathion emulsion; applied as a 20 per cent solution, three applications, approximately 4.5 liters of spray per tree at each application.

sesame into sacks and $0.0883 per quintal for packing citrus fruits into cartons.[1] It is anticipated that the women will pack these produce and the men will float them on rafts to Gambela although it may be more convenient, organizationally, to transport them to warehouses in Gambela before packing.

Table A.9 presents a summary of total costs (excluding financial charges). These data have to be compared with those in Table A.6 to obtain net returns for each year of operation.

Financial Costs

Three different types of loans are assumed feasible to finance the proposed improvements: a crop loan account to cover short term-operations; medium-term loan arrangements to cover the purchase of equipment; a long-term loan to meet the costs of establishing the citrus orchards. Annual rates of interest are assumed to be 8 per cent for crop loans, and 7 per cent for overdraft accommodation medium- and long-term loans.[2]

Crop loan charges have been computed on a monthly basis for the purchase of inputs made in advance of cash income. Sesame is harvested in March and after the third year, citrus fruits are harvested in January and February. It was therefore assumed that crop loans are to be taken out in monthly installments beginning in July with the purchase of insecticides in preparation for the August-September spraying period. Repayments are then made at the end of February. Inputs covered by the crop loan are: sprays, packing cartons and labor requirements to the end of February.

Medium-term loan accommodation is to be used to meet the costs of new grain cribs, including labor for

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[1]Calculated on the basis of cartons containing 17 kilograms: see Robert C. Rock, Cost of Picking, Hauling and Packing California and Arizona Citrus Fruits, 1958-59 (Berkeley: Agricultural Extension Service, University of California, 1960), p. 6.

[2]Harry J. Robinson and Ato Mammo Bahto, An Agricultural Credit Program for Ethiopia, Report No. 9, SRI Project IU-6350, prepared for the Technical Agency, Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, January, 1969), p. 187.

TABLE A.9 Agnale: Summary of annual total costs for inputs (excluding financial charges), budget model (t=0,...,10)

Year	Labor		Seed		Spray	Packing	Depreciation		Total input costs		
	Non-cash	Cash	Non-cash	Cash	Cash	Cash	Non-cash	Cash	Non-cash	Cash	Total
	dollars[a]										
0	2,620.08	-	242.20	-	-	-	66.89	-	2,929.17	-	2,929.17
1	2,373.11	27.50	225.23	3.01	.77	.50	52.82	17.80	2,651.16	49.58	2,700.74
2	2,023.98	46.83	209.70	5.35	1.37	.80	38.60	31.60	2,272.28	85.95	2,358.24
3	1,726.60	73.70	186.53	8.82	2.26	1.30	24.53	54.40	1,937.66	140.48	2,078.14
	Years 4-10: High-level yields										
4	1,421.87	729.51	158.77	12.29	1,349.64	42.52	10.30	147.08	1,590.94	2,281.04	3,871.99
5	1,356.96	831.96	160.55	15.20	1,349.69	79.33	9.89	150.18	1,527.40	2,423.66	3,951.06
6	942.95	986.05	-	75.48	1,392.90	112.11	9.31	725.58	952.26	3,292.12	4,244.38
7	833.86	1,080.24	-	64.96	1,384.98	141.81	8.90	725.88	842.76	3,397.87	4,240.63
8	764.96	1,165.96	-	58.09	1,379.82	167.85	8.42	727.88	773.88	3,499.59	4,272.97
9	713.35	1,265.31	-	55.19	1,376.61	191.72	8.48	730.18	721.83	3,619.01	4,340.84
10	683.85	1,373.32	-	54.60	1,374.67	213.06	8.48	731.18	629.33	3,746.83	4,349.16
	Years 4-10: Low-level yields										
4	1,421.88	660.36	158.77	12.29	1,349.64	18.69	10.30	147.08	1,590.95	2,188.05	3,779.01
5	1,356.96	704.94	160.55	12.50	1,349.69	35.66	9.89	150.18	1,527.40	2,252.97	3,780.37
6	941.94	814.58	-	75.48	1,392.90	53.22	9.31	725.58	951.25	3,061.76	4,013.01
7	956.48	872.25	-	77.35	1,393.67	70.36	8.90	725.88	965.38	3,139.51	4,104.89
8	969.38	933.28	-	78.83	1,394.34	89.62	8.32	726.88	977.70	3,222.95	4,200.65
9	980.82	999.11	-	82.15	1,395.48	105.73	8.48	728.19	989.30	3,310.66	4,299.96
10	999.01	1,075.66	-	86.61	1,397.07	123.83	8.48	729.19	1,007.49	3,412.36	4,419.85

[a]U.S. dollars.

construction, and the purchase of improved equipment. The charges are amortized to repay principal and interest on each annual amount borrowed over a seven year period.

The long-term loan is considered as a special arrangement with an appropriate credit agency.[1] The arrangement has to be drawn up in a way that will give encouragement to unsophisticated agricultural systems having particular potential for developing crop production which requires long-term capital investments. When citrus orchards begin to bear fruit the first years of production are quite low, e.g., around 6-14 per cent of maximum production in the first year of fruiting. Full repayment on the long-term loan will be completed in the twentieth year of operation (t=20), the payment of the first will not begin until the sixth year in order to avoid over-burdening the people with the responsibilities of heavy indebtedness before the principal cash crops begin to yield a substantial harvest. Furthermore, in view of the initial fraction of maximum yield to be expected, weighting has been applied to the debt installments so that at the commencement of repayment (t=6) one-fifteenth of the accrued debt is repaid; the following year (t=7), one-fourteenth of the outstanding debt is repaid; in the final year (t=20), the final installment clears off the full amount of outstanding debt.

In introducing technological improvements into an unsophisticated agricultural system, it appears important that the rewards should be both immediate and appreciable. Thus, depreciation charges for the orchards do not commence until repayments on the long-term loan also commence. In this way a higher margin of net income is available for distribution in a manner determined by the village community and their leaders. Details of the financial charges are contained in Table A.10.

Budget Summary

The complete budget model is summarized in Table A.11; only aggregated income and expenditures are recorded. Income and total costs are a mixture of cash and non-cash quantities, financial charges are wholly cash

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[1]The Development Bank of Ethiopia would be an appropriate agency if it were willing to support such a development program.

TABLE A.10 Agnale: Annual financial charges and net financial costs, budget model (t=0,...,10)

Item	0	1	2	3	4	5	6	7	8	9	10
	Annual financial charges and costs at indicated year										
	dollars[a]										
					Years 4-10: High-level yields						
Crop loan charges	-	.84	1.44	2.26	87.79	89.78	201.04	180.93	167.45	163.04	156.86
Overdraft repayment	-	-	-	-	-	-	-	-	-	-	-
Med. term loan charge	-	21.82	39.19	66.58	93.96	99.75	132.78	151.26	161.73	200.69	252.35
Long term loan charge	-	-	-	-	-	-	106.78	161.37	217.53	270.03	331.66
Total financial charges	-	22.66	40.63	68.84	181.75	189.53	440.60	493.56	546.71	633.76	740.87
Less depreciation fund	-	17.80	31.60	54.40	147.08	150.18	725.58	725.88	727.88	730.18	731.18
Bal. of depreciation fund c/f at 4% interest	-	-	-	-	-	-	-	296.38	549.85	760.26	890.95
Net financial costs	-	4.86	9.03	14.44	34.68	39.35	-284.98	-328.70	-731.02	-856.68	-881.26
					Years 4-10: Low-level yields						
Crop loan charges					86.42	87.26	197.64	198.79	198.92	202.50	206.21
Overdraft repayment					-	376.45	-	-	-	-	-
Med. term loan charge					93.96	99.75	132.78	151.26	161.73	200.69	252.35
Long term loan charge					-	-	106.78	161.37	217.53	270.03	331.66
Total financial charges					180.48	563.46	437.20	511.42	578.28	673.22	790.22
Less depreciation fund					147.08	150.18	725.58	725.88	726.88	728.19	729.19
Bal. of depreciation fund c/f at 4% interest					-	-	-	299.91	534.94	710.92	796.52
Net financial costs					33.31	413.28	-288.38	-514.37	-683.58	-765.89	-735.49

[a]U.S. dollars.

TABLE A.11 Agnale: Summary of budget model accounts (t=0,...,10)

Item	0	1	2	3	4	5	6	7	8	9	10
	Annual account summary at indicated year										
	dollars[a]										
					Years 4-10: High-level yields						
Gross income	4,496.64	4,605.76	4,698.02	4,821.76	8,793.93	12,325.14	15,459.46	18,383.52	20,950.34	23,353.50	25,560.12
less total costs (excluding financial charges)	2,929.17	2,700.74	2,358.24	2,078.14	3,871.99	3,951.06	4,224.38	4,240.63	4,272.97	4,340.84	4,349.16
Net returns	1,567.47	1,905.02	2,339.78	2,743.62	4,921.94	8,374.08	11,215.08	14,142.89	16,677.37	19,012.66	21,210.96
less net financial costs	-	4.86	9.03	14.44	34.68	39.35	-284.98	-528.70	-731.02	-856.68	-881.26
Net income	1,567.47	1,900.16	2,330.76	2,729.18	4,887.26	8,334.73	11,500.06	14,671.59	17,408.39	19,869.34	22,092.22
					Years 4-10: Low-level yields						
Gross income					6,535.59	8,187.64	9,879.85	11,573.11	13,458.37	15,061.10	16,884.03
less total costs (excluding financial charges)					3,779.01	3,780.37	4,013.01	4,104.89	4,200.65	4,299.96	4,419.85
Net returns					2,756.58	4,407.27	5,866.84	7,468.22	9,257.72	10,761.14	12,464.18
less net financial costs					33.31	413.28	-288.38	-514.37	-683.58	-765.89	-735.49
Net income					2,723.27	3,993.99	6,155.22	7,982.59	9,941.30	11,527.03	13,199.67

[a]U.S. dollars.

expenditures. There is adequate data in foregoing tables to separate cash from non-cash items if this information is needed.

Additional Requirements

Supervision

The presence of a technically qualified supervisor has been mentioned several times; supervision is indispensible for these proposed changes. An experienced Ethiopian extension agent must be employed to direct agricultural operations and the introduction of technological changes. The agent must work closely with the village elders whose sympathy and cooperation is essential since any instructions to village cultivators must be given through the village authority. Estimated expenses of the extension agent are given in Table A.12. When fully established an agent should be able to supervise the operation of 10-15 villages.

Infrastructure

Gambela is accessible by road from Addis Abeba. The journey is extremely rough but the Imperial Ethiopian Government has plans to improve this road during the next three to five years. From Gambela the feeder road is extremely difficult to drive and is impassable during the wet season. The full development of this area will require a farm road to be constructed; the cost is estimated at $2,400 per kilometer.[1] However, Gambela is readily accessible by canoe and raft which can be used to transport cash crops to assembly warehouses in Gambela.

The collection and packing of citrus fruits and sesame requires organization. A farmers' cooperative is already organized in Gambela. The established cooperative has packing and warehouse facilities for farmers and cultivators in the local vicinity. These facilities may well be expanded to accommodate the needs of villages such as Agnale for these types of services.

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[1]Carl F. Miller, _et al._, _Systems Analysis Methods . . ._, p. 114.

TABLE A.12 Agnale: Estimated annual costs for extension agent, equipment, and supporting costs, 10-15 villages during budget period (t=0,...,10)

Item	Annual additional costs at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
Salary	-	3,600	3,720	3,840	3,960	4,080	4,080	4,200	4,200	4,320	4,320
Per diem	-	400	400	400	400	400	400	400	400	400	400
Total personnel costs	-	4,000	4,120	4,240	4,360	4,480	4,480	4,600	4,600	4,720	4,720
Vehicle cost[b]	-	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387
Vehicle maintenance	-	400	400	400	400	400	400	400	400	400	400
Fuel	-	800	800	800	800	800	800	800	800	800	800
Total vehicle costs	-	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies	-	200	200	200	200	200	200	200	200	200	200
Total costs	-	6,787	6,907	7,027	7,147	7,267	7,267	7,387	7,387	7,507	7,507

[a]U.S. dollars.

[b]Depreciation rate 33% p.a. capital outlay of $3,640 for Land Rover amortized at 7% p.a. over three years.

Source: United States Agency for International Development, Shashamanne Farm Development Project, Project Proposal and Financial Analysis (Addis Abeba: USAID/Ethiopia, Agricultural Division, March, 1969), p. 32. (Mimeographed.)

APPENDIX B

CHILALO AWRAJA CASE STUDY

APPENDIX B

CHILALO AWRAJA CASE STUDY

Introduction

Chilalo Awraja in the province of Arusi was selected for a special development program by mutual agreement between the Ethiopian and Swedish governments. Following the agreement,[1] the Swedish International Development Agency established a cooperative technical assistance unit--the Chilalo Agricultural Development Unit (CADU)--to develop a balanced program of economic development, incorporating the local extension agents of the Ethiopian Ministry of Agriculture. The program is designed to use modern agricultural inputs, improved animal-powered technology, and engine-powered technology: to improve market facilities; and to incorporate a comprehensive range of domestic and social programs along with the technological changes.

This case study represents one of the many scattered farmsteads in the area; a local small town provides a market for both the sale of farm produce and the purchase of farm inputs and family requirements. The principal town of Arusi Province is Asela (location: 7°50' North, 39°7' East); other small rural towns in Chilalo Awraja are Sagure, Digelu, Gonde, Iteya, Hurutta, Yeloma, and Dera. Observations of a survey of 12 farmers[2]

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[1]The Governmental agreement on the Chilalo Agricultural Development Unit (CADU) was signed on September 8, 1967. Chilalo Agricultural Development Unit, CADU Semi-Annual Report 1967/68 (Addis Abeba: Swedish International Development Agency, January, 1968), p. 1.

[2]The author and Ato Seyoum Solomon conducted a survey of 12 farmers in the vicinity of Asela. Three visits were made to each farmer over the period October, 1968 through March, 1969.

and published data from CADU's experience have provided the basis on which the case for the initiating year (t=0) has been established. A farming system which employs oxen power, well-established in the area, is represented by this case although farmers are showing increasing interest in engine-powered technology.

Chilalo Awraja, is located on the eastern side of the upper Rift Valley about 150 kilometers south of Addis Abeba. Chilalo Mountain, rising to 4,500 meters, dominates the area, about one million hectares, of which about one-quarter is cultivated. Most crops are grown between the elevations of 2,000-2,500 meters. Some parts are too rugged to be cultivated by engine-powered equipment; however, there is a substantial area on which engine-powered technology is practicable.

The total population of Arusi Province has been estimated to be 722,500. The rural population is estimated to be 690,600, of which 52.3 per cent (361,400) live in the Chilalo Awraja.[1] The natural rate of increase is estimated at 18.2 per 1,000.[2]

Climatic data are recorded in Table B.1. The area is moist for most of the year: June-December is an extremely wet period; December is without rainfall. The annual average rainfall, ranging from 700-1,000 mm. appears adequate for the production of a wide variety of rain-fed crops including wheat, barley, maize, _teff_, flax (linseed) and other pulses. The soils are described as "dark brown clays developed from calcareous lava and bedrock with some red acid soils."[3] Soil tests indicate no critical limiting factors to crop production in the area.[4] The land is fairly fertile and the area has excellent potential for modern agricultural technology.

The area is in a state of economic transition. Fundamental changes appear to be taking place in farmers'

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[1]Imperial Ethiopian Government, _Report on a Survey of Arussi Province_, National Sample Survey, Report No. 2 (Addis Abeba: Central Statistical Office, July, 1966), pp. 4-7.

[2]_Ibid._, p. 13.

[3]Kline, _et al._, _op. cit._, Pt. II, p. 36.

[4]_Ibid._, Pt. II, p. 39.

TABLE B.1 Chilalo: Climatic data and distribution of crop operations by calendar months, budget model initiating year (t=0)

Item	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Seasons	Small rains				------------	------Wet------		------------				
Rainfall (1967)[a] (mm.)	0.5	85.3	45.5	87.5	69.7	172.9	149.8	140.3	66.8	65.3	-	1.3
Mean temperature (1967)[a]												
Maximum (°C)	24.1	24.3	23.3	22.7	22.4	19.4	18.6	19.1	20.5	19.5	19.6	21.4
Minimum (°C)	8.6	10.2	11.4	11.0	10.4	11.1	10.5	10.0	10.5	6.5	6.5	6.4
Crop operations												
Wheat		——plow	(3 times)——	——		-plant-	————	——weed	———	———	——harvest	——
Barley		——plow	(3 times)——	——	-plant-		————	——weed	———	———	-harvest-	
Maize	plow	(2-3 times)—	-plant——				———	——weed	———	———	-harvest-	
Teff		——plow	(4 times)——	——	-plant-		————	——weed	———	———	-harvest-	
Flax (linseed)		plow	(1 time)——		-plant—		————	——weed	———	———	——harvest	——
Peas		plow	(1 time)——	——	-plant—		————	——weed	———	———	-harvest-	
Beans	———	——plow	(3 times)——	——		-plant-	————	——weed	———	———	-harvest-	
Fallow	times)----	--------	--------	--------	------		break soil,	plow,	soil burn,	plow	(many	

[a]Chilalo Agricultural Development Unit, Results of Trials and Observations of Field and Forage Crops at the Kulumsa Farm and in Asella (Addis Abeba: Swedish International Development Agency, June, 1968), p. 5.

aspirations and attitudes as the modernization process progresses. Farmers appear increasingly to recognize that modern agricultural tillage equipment is superior to traditional oxen cultivation in terms of time and quality of cultivation, for cereal production, providing means can be found to buy or hire the appropriate equipment.[1] The use of engine-powered equipment is expanding through the CADU tractor and implement hire services. Owners of larger farms (20 hectares and above) are willing to pay the relatively high charges to hire cultivating services. Some large farmers already own tractors and others are in the process of acquiring tractors and equipment, either independently or on a cooperative basis.

The area has a well established commercial economy; a significant proportion of farm produce is marketed locally although small farmers also provide for most of their own subsistence needs of food and fiber. There are wide fluctuations in the annual cycle of income and expenses. Incomes, negligeable in June, October, and December, increase slightly January through May, and rise to maximum flow in September as the previous year's harvest is being sold. Livestock sales are restricted to January, May, and October.[2] Thus, farmers have commercial experience and some ability to plan annual farm activities within the constraints of fluctuating income flows. These features, along with the existence of a monetized economy and a fairly sophisticated level of rural town life, provide a fairly substantial basis for the development of the various specializations of the modernization process.

Proposals to improve the agricultural economy are based on the introduction of improved tools and equipment, improved crop varieties and better cultivation practices. The possibility of introducing new products is remote; rather, emphasis is put on improving the efficiency of the established economy.

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[1]Bo Bengtsson, Cultivation Practices and the Weed, Pest and Disease Situation in Some Parts of the Chilalo Awraja (Addis Abeba: Chilalo Agricultural Development Unit, Swedish International Development Agency, March, 1968), p. 15.

[2]Lars Leander, A Case Study of Peasant Farming in the Digelu and Yeloma Areas, Chilalo Awraja, Ethiopia, Report No. 22 (Addis Abeba: Chilalo Agricultural Development Unit, Swedish International Development Agency, January, 1969), p. 81.

Two strategies have been examined as alternative approaches to improving economic efficiency. In strategy I tools and equipment in current use are to be replaced by improved designs and more powerful oxen. In strategy II less equipment is to be owned by the individual farmer and a tractor hire service is to be established for major tillage and harvest operations, weeding to remain a hand operation.

Farmers produce a substantial amount of total output for consumption. Subsistence crop requirements are the first concern of the farmer in planning the deployment of his resources. The estimated requirements for subsistence consumption are shown in Table B.2(a) and the necessary tools and equipment to be owned by the farmer for the two strategies are recorded in Table B.2(b).

Present Agricultural Economy

The People and Their Habitat

The people of Chilalo belong to the major Ethiopian ethnic groups: Galla constitute the majority and Amhara, the minority. Farmers live with their families either in the small rural towns or on scattered farmsteads.

A recent survey[1] shows a small proportion (5.1 per cent) of farmers have occupations at which wages are earned to supplement their income in order to support the farm family. The average size of a farm family is 6.3 persons[2] and the average size of farms is 8.1 hectares of which 5.1 hectares is cropped and the remainder is grazed. The average farm has 2.4 fragments.

The area has been settled by this population for several generations. Some 52 per cent of farmers are tenants. Four different kinds of tenancy agreements

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[1]Chilalo Agricultural Development Unit, General Agricultural Survey of the Project Area (Addis Abeba: Swedish International Development Agency, July, 1968), pp. 11-18.

[2]

Persons	Equivalent Consumption Unit
3.1 adults	3.1 units
3.2 children	1.6 units
6.3 Average	4.7 Average

TABLE B.2 Chilalo: Basic assumptions
a. Subsistence crop requirements, budget model (t=0,...,10)

Item	Crop						
	Wheat	Barley	Maize	Teff	Linseed	Peas	Beans
	quintals per annum						
Average per capita consumption in Arusi[a]	.2181	.7955	.1931	.2986	n.a.	.1279	.1279
Initiating Year (t=0)							
Domestic requirements[b]	1.25	4.54	1.10	1.71	.58[c]	.73	.73
Animal feed (2 oxen,[d] 1 horse, 1 donkey)		6.00					
Total (t=0)	1.25	10.54	1.10	1.71	.58	.73	.73
Strategy I--additional requirements (t=1,...,10)							
(Aug.-Dec.) 1 man	.52	1.90	.46	.71	-	.31	.31
(Nov.-Jan.) 1 man	.31	1.14	.28	.43	-	.19	.19
Total	.83	3.04	.74	1.14	-	.50	.50
Total (Strategy I, t=1,...,10)	2.08	13.58	1.84	2.85	.58	1.23	1.23
Strategy II (t=1,...,10)							
Domestic requirements	1.25	4.54	1.10	1.71	.58	.73	.73
Animal feed (1 horse, 1 donkey)	-	2.00	-	-	-	-	-
Additional labor (Nov.-Dec.)	.16	.57	.14	.22	-	.10	.10
Total (Strategy II, (t=1,...,10)	1.41	7.11	1.24	1.93	.58	.83	.83

[a]Eichberger, "Food Production and Utilization . . . ," p. 21.

[b]Average household of 5.7 consumption units (4.7 plus 1 resident laborer).

[c]For domestic use only.

[d]C. K. Laurent, "The Use of Bullocks for Power on Farms in Northern Nigeria," Bulletin of Rural Economics and Sociology, III, No. 2 (October, 1968), 241.

TABLE B.2 Continued
b. Tools and equipment for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Equipment	Initiating year (t=0)				Strategy I (t=1,...,10)			Strategy II (t=1,...,10)		
	Unit acquisition price	Total cost[a]	Annual depreciation Non-cash	Annual depreciation Cash	Unit acquisition price	Total cost[a]	Annual depreciation (cash)	Unit acquisition price	Total cost	Annual depreciation (cash)
	-----dollars[b]-----		----per cent----		-----dollars[b]-----		--per cent--	-----dollars[b]-----		--per cent--
Sickles	.65	3.90			1.40[c]	8.39		1.40[c]	8.39	
Hoes	.40	2.00			.86[c]	4.30		.86[c]	4.30	
Shovels	.50	1.00			1.07[c]	2.15		1.07[c]	2.15	
Saws	.40	.40			.86[c]	.86[c]		.86[c]	.86	
Axe	.80	.80			1.72[c]	1.72		1.72[c]	1.72	
Pickaxe	1.20	1.20			2.58[c]	2.58		2.58[c]	2.58	
Total hand tools		9.30		13.00		20.00	13.00		20.00	13.00
Oxen	36.00	72.00	16.67		64.00	128.00[d]	16.67		-	
Plow (local)	2.80	8.40		39.20		-				
Ox sledge and miscellaneous oxen equipment	7.20	14.40		39.20		-			-	
Improved ox equipment										
Tool bar		-			61.00	61.00[e]	12.00		-	
Plow		-			40.00	40.00[e]	12.00		-	
Harrow		-			25.00	25.00[e]	12.00		-	
Planter		-			44.00	44.00[e]	12.00		-	
Cart		-			120.00	120.00[f]	12.00		-	
Spare parts		-			40.00	40.00[g]	12.00		-	
Total oxen equipment	.80	22.80				330.00			-	
Grain cribs	.80	8.00		10.00	40.00	80.00	5.00	40.00	80.00	5.00
Total		112.10				458.00			100.00	

[a]Tools and equipment not fully depreciated in year t valued at cost of acquisition.

[b]All dollar values for these analyses are U.S. dollars.

[c]Estimated local cost for improved hand tools.

[d]Estimated local cost for pair of improved oxen.

[e]Kline, *et al.*, *op. cit.*, Pt. II, p. 186.

[f]*Ibid.*, Pt. II, p. 194.

[g]*Ibid.*, Pt. II, p. 284.

prevail.[1] A generalized situation has been adopted for the case study: the landlord is entitled to one-tenth of the gross value of farm product (as the landlords share of land tax) and one-third of the balance of gross farm product; in return, the landlord pays a cash contribution of one-third of the seed costs.[2]

Agricultural Practices

A wide variety of crops is grown annually. There is only one season as shown by the climatic data and distribution of agricultural operations contained in Table B.1.

The estimate of crop areas in the initial year of the case study (t=0) was based on the CADU survey of crops grown in 1967.[3] In subsequent years, these areas are adjusted in the budget model according to a decision-making rule to be discussed later. Under current agricultural practice, there is a general tendency to overgraze.[4] Moreover, most farmers lack the technical skills and capital resources to make a significant income out of livestock. Therefore, the budget model has been developed in terms of concentrating the farmer's efforts on improving crop production and reducing the livestock enterprises, a minimum area being left as fallow which can be grazed by livestock. In strategy I, cultivated land is increased to a maximum of 6.6 hectares from 5.1 hectares in the initiating year. In strategy II, no work oxen are to be kept by the farmer, therefore the maximum cropped area is raised to 7.1 hectares.

A wide range of hand tools is used along with the local oxen plow. The following tools were observed in the survey of 12 farmers:

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[1] Chilalo Agricultural Development Unit, General Agricultural Survey of the Project Area . . ., p. 18.

[2] Based on information from Leander, op. cit., p. 89.

[3] Chilalo Agricultural Development Unit, General Agricultural Survey of the Project Area . . ., p. 20.

[4] U.S. Agency for International Development, "Shashamanne Farm Development Project . . . ," p. 8.

1. Sickle, machid--common throughout Ethiopia, the principal harvesting implement. The local sickle is made with a saw-toothed cutting edge. The average number owned was six and the local cost was \$0.50-0.80[1] each.

2. Hoe, gesso--common throughout the Empire, the principal cultivating hand tool. This is a short-handled hoe with a flat blade set at right angles to the handle (60 cm. length). The number owned was four or five and the local cost was \$0.40 each.

3. Shovel, akafa--a standard long-shafted (about 1.5 meters) shovel. Average number owned was one and the local cost about \$0.50 each.

4. Saw, megaze--similar to the American or European tool. Average number owned was one and the local cost was \$0.40 each.

5. Adze, mekotkocha--a two-edged metal head on a shaft, a widely used chopping and digging tool. One edge is sharpened for chopping and the other edge is pronged for digging. The head is about 30 cm. long and the wooden shaft, set into the head at right angles, is about 90 cm. long. Farmers interviewed owned one each and estimated its cost at \$0.60.

6. Axe, metrebia--similar to the American or European tool. Some farmers owned none, others owned as many as five axes. Estimated cost was \$0.80 each.

7. Pickaxe, doma--similar to the American or European tool. Farmers interviewed owned either none or one; estimated value was \$1.20 each.

8. Local plow, maresha--

> . . . consists of a bent wooden beam with a small iron [or steel] point. This plough, being almost the only farm implement, is very inefficient since it only breaks up the surface of the soil and lacks mould-boarding properties. This also influences

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[1]All dollar values are U.S. dollars.

> weed growth which is very little checked [sic]. However, many farmers do not consider the ploughing as anything else but [a] means of seed-bed preparation. Although farmers admit that they have many weeds in their fields . . . there is only one-fifth of interviewed farmers who regard ploughing as being a weed control method as well.[1]

Using the plow strains both oxen and operators. Oxen work in two to three hour stretches and then must be given rest for about an hour. Working steadily for a full day under ideal conditions a farmer might prepare one-half hectare of land with a pair of oxen. Farmers interviewed owned three or four plows and estimated the local cost to be about $2.70.

Regular plowing begins with the small rains; breaking and plowing fallow land is a lengthy process which is begun in September or October. The third plowing prepares the seed bed; the planting operation includes a covering in which the plow is used again. In the case of flax and peas there is only one plowing, in the case of _teff_ there are four preparatory plowings before the seed is trampled into the soil by men and animals.[2]

Labor requirements in the initiating year (t=0) are provided by the farmer and one resident laborer, assisted by the farmer's wife at times of critical demand. The custom of laboring for cash wages, resident laborers receiving both cash wages and board and lodging, is established in this area. Resident laborers receive $30.00 to $40.00 per annum in cash. Total labor costs were computed on the basis of estimated man-hour requirements for the year evaluated at $0.05 per man-hour. During the initiating year one resident hired man is not fully occupied for the whole year; his board and lodging are estimated at $59.00 per annum. In the operational years of the budget model one man is fully occupied and a second is hired for the weeding period; total board and lodging are estimated at $110.00 per annum. The estimated value for board and lodging was deducted from total wage costs to estimate the annual cash wage for labor. Any cash amount above the $30-40 taken by hired laborers can be assumed to be cash taken by the farmer.

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[1]Bengtsson, _op. cit._, p. 5.

[2]_Ibid._, pp. 5-10.

The concentration of people in the area is quite heavy (36.14 persons per square kilometer, calculated over the entire area of the Awraja; 114.56 persons per square kilometer, calculated over the cultivated area). This population concentration contrasts with that of the other three case studies. In Chilalo there is a well organized land market and rent has been included in the budget model.

Other inputs include seeds, sacks, transportation, and storage. In the initiating year it has been assumed that farmers retain their own seeds from previous seasons; in the budget model improved varieties are introduced in the first operational year (t=1). Sacks are included at a standard charge of $0.10 per quintal. Grain is usually transported on the backs of donkeys which are usually owned but can be hired at a standard charge of $0.16 per quintal.

Until consumed or sold grain is stored in basket-like grain cribs (_gotera_). The cribs in this area tend to be smaller than those described at Agnale. Chilalo cribs, constructed of clay, _teff_ straw and manure, have capacities from 2.5 to 6.5 quintals and last 10-15 years.[1] The level of attrition for produce stored in these cribs is a current subject of controversy.[2] For the purposes of this case study the farmer is assumed to have 10 cribs with a total capacity of 50.67 quintals,[3] _teff_ and linseed being stored inside the farmhouse. Waste level was assumed to be 10 per cent in the initiating year to be reduced to 3 per cent as improved storage facilities are introduced.

Production and Value of Crops

Estimates for crop yields for the initiating year have been made by reference to the various sources observed in CADU literature for the 1967 season.[4] Some adjustments to allow for the possibility of over estimating yields were

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[1]Clarence J. Miller, _Production of Grains and Pulses . . ._, p. 33.

[2]_Ibid_.

[3]1 x 3.57; 6 x 4.60; 3 x 6.50.

[4]Chilalo Agricultural Development Unit, _Crop Sampling in the Chilalo Awraja . . ._, pp. 3-9.

made on the basis of the sample survey carried out in 1968.[1] These yield assumptions are recorded in Table B.2(c).

The area required to grow crops for domestic consumption has been calculated on the basis of yields, giving due allowance for waste, and the remainder is considered as marketable surplus. In years subsequent to the initiating year (i.e., t=1,...,10) two levels of production have been used; the calculation of area for subsistence requirements is based on the lower yield since the farmer must at least cover his minimum family requirements.

Prices have been held constant for the entire eleven year period. Assumed prices are those reigning in Addis Abeba during the 1967-68 season,[2] less costs of transportation of $0.48 per metric ton for the haul of 150 kilometers.[3] Assumed prices are also contained in Table B.2(c).

Technological Improvements

Improvements in mechanization can follow the two basically different courses represented by strategies I and II. The objectives of improving the level of mechanization in this system of farming are (1) to relieve the heavy demand for labor requirements which occur during December-March, and (2) to facilitate better cultivation techniques in order to realize the higher yield potential of improved crop varieties. The total aim of technological improvements includes increasing gross income, economizing on the use of resources and introducing appropriate mechanical assistance to cope with the changes. These improvements include: (1) increasing labor capacity and land productivity through the introduction of improved tools and equipment; (2) reducing attrition through the introduction of improved storage facilities; (3) increasing the productivity of land through the introduction of improved crop varieties; (4) increasing land productivity

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[1]Leander, op. cit., p. 46.

[2]Carl F. Miller, et al., System Analysis Methods . . ., p. 115.

[3]Ibid., p. 101.

TABLE B.2 Continued
c. Prices and annual yield assumptions, budget model (t=0,...,10)

Crop	Yield level	Price	Years of use for crop variety	Annual yield at indicated year: 0	1	2	3	4	5	6	7	8	9	10
		$/q.[a]		quintals per hectare										
Wheat	High	8.72	t=0:Local; t=1,...,6:Kentana Frontana x Mayo;[b] t=7,...,10:Nainari 60[c]	9.0	15.9	19.8	23.8	27.8	31.7	33.1	34.5	35.4	37.2	38.6
	Low				10.6	11.9	13.2	14.6	15.9	16.7	17.4	18.2	19.0	19.8
Barley	High	6.32	t=0:Local; t=1,...,10:Unitan[c]	10.0	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19.0
	Low				10.4	10.8	11.3	11.8	12.2	12.6	13.1	13.6	14.0	14.5
Maize	High	5.52	t=0:Local; t=1,...,10:Kitale H613B[c]	16.0	25.0	27.8	30.6	33.3	36.1	38.9	41.7	44.4	47.2	50.0
	Low				16.7	17.6	18.6	19.5	20.4	21.3	22.3	23.2	24.1	25.0
Teff	High	10.48	t=0:Local; t=1,...,10: DZ01-200[b]	7.0	12.0	13.3	14.7	16.0	17.3	18.7	20.0	21.3	22.6	24.0
	Low				8.0	8.4	8.9	9.3	9.8	10.2	10.6	11.1	11.5	12.0
Flax	High	9.92	Local[c]	7.0	8.0	8.9	9.7	10.6	11.5	12.4	13.3	14.2	15.1	16.0
	Low				7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0
Peas	High	7.92	Local[b]	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0
	Low				8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0
Beans (Broad)	High	6.00	Local[b]	8.0	8.8	9.7	10.6	11.4	12.2	13.1	14.0	14.8	15.6	16.5
	Low				8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0

[a]U.S. dollars.

[b]Clarence J. Miller, Howard W. Ream, Frank V. Beck, and Alemayehu Wodejeneh, Production of Grains and Pulses in Ethiopia, Report No. 10, SRI Project IU-6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, January, 1969), p. 133.

[c]Chilalo Agricultural Development Unit, Results of Trials and Observations . . ., pp. 17-73, and Chilalo Agricultural Development Unit, Crop Sampling in the Chilalo Awraja, Arussi Province (Addis Abeba: Swedish International Development Agency, June, 1968), pp. 3-9.

by improving weeding and cultivation techniques;[1] (5) increasing total production through increasing the area under crops. The agriculture of Chilalo is based essentially on cereal growing and it is proposed to develop this potential in view of a fairly stable market for major cereals.[2]

Increasing both crop yields and required cultivation raises farm labor requirements. These demands can be met by hiring labor as required since the practice of working for wages is already established. Furthermore, the population is expanding at a modest rate and, the availability of a gradually expanding labor supply is a reasonable assumption.

Since the farmer grows cereals for both subsistence consumption and cash sales, a decision-making algorithm was included in the budget model for the operational years ($t=1,\ldots,10$) in order to determine the distribution of available area among the various crops. Domestic requirements have been calculated according to the number of consumption units in the household.[3] In the case study the principal cash crop is wheat. There are marketable surpluses for all crops and the farmer changes his cash cropping pattern from year to year as relative market prices change.

In the area, wheat, barley and flax are the principal cash crops; maize and broad beans are important sources of revenue. These two crops are also particularly useful as cleaning crops since the wide rows facilitate good weeding. The assumption made to determine the area of cash crops was that, after the area necessary to meet the requirements for domestic consumption (calculated on the basis of low-level yields) had been deducted from the total area available, two-thirds of the remaining area is to be devoted to the principal cash crop and one-sixth each to maize and beans. The criterion for making the decision to

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[1]Chilalo Agricultural Development Unit, Results of Trials and Observations . . ., pp. 55-60.

[2]U.S. Agency for International Development, "Application . . .," p. 14.

[3]Eichberger, "Food Production and Consumption . . .," p. 21.

grow wheat, barley or flax is the operating margin of the previous years.[1]

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[1]The decision-making algorithm to determine the distribution of total area among seven different crops is defined as follows:

<u>Variables (Xi)</u>

<u>Crop yield:</u> Y_{Xi}, i =,...,7 (decisions based on low-level yields)

Total area for individual crops: A_{TXi}

Crop area for subsistence requirements: A_{SXi}

Crop area for cash marketing: A_{CXi}

Physical outputs--wheat, barley, maize, *teff*, flax, peas, beans: i=1,...,7 (quintals)

Physical inputs--labor for each crop: i=8,...,14 (man-hours)

--seed for each crop: i=75,...,21 (quintals)

--fertilizer for each crop: i=22, ...,28 (quintals)

--sacks: i=29, ($X_{29} = \sum_{i=1}^{7} Y_{Xi}$, where one sack holds one quintal)

--domestic requirement: H_{Xi}

Other values--waste level: W_{Xi} (per cent)

--prices: P_{Xi} (dollars per unit)

Machine rates--plowing: r_{X30} (hours per hectare)

P_{X30} (costs per hour)

--planting: r_{X31} (hours per hectare)

P_{X31} (costs per hour)

--discing: r_{X32} (hours per hectare)

P_{X32} (costs per hour)

--combining: r_{X33} (hours per hectare)

P_{X33} (costs per hour)

Strategy I

Preliminary Definitions

$$X_{i\,(t)I} = (Y_{X_{i(t)I}})(A_{TX_{i(t)I}});$$

$$A_{SX_{i(t)I}} = H_{X_{i(t)I}}/(1-W_{X_{i(t)I}})(Y_{X_{i(t)I}});$$

$$A_{TX_{i(t)I}} = A_{SX_{i(t)I}} + A_{CX_{i(t)I}}, \text{ for } i=1,\ldots,7$$

where t is the year of operation.

$$E_{1\,(t)I} = \frac{(X_{1\,(t-1)I})(1-W_{X_{1(t-1)I}})(P_{X_{1(t-1)I}})}{A_{TX_{1(t-1)I}}} - \left[\sum_{i=8,15,22} \frac{(Xi_{(t-1)I})(P_{X_{i(t-1)I}})}{A_{TX\,(t-1)I}} + (Y_{X_{1(t-1)I}})(P_{X_{29(t-1)I}})\right];$$

$E_{2\,(t)I}$: same form of equation as $E_{1\,(t)I}$, use X_2 in place of X_1, X_9 in place of X_8, X_{16} in place of X_{15}, X_{23} in place of X_{22};

$E_{3\,(t)I}$: same form of equation as $E_{1\,(t)I}$, use X_5 in place of X_1, X_{12} in place of X_8, X_{19} in place of X_{15}, X_{26} in place of X_{22}.

Determination of Cash Crop Areas

1. Wheat ($A_{CX_{1(t)I}}$)

   a. For t=0: $A_{CX_{1(t)I}} = A_{SX_{1(t)I}}$

   b. For t=1,...,10:

   If $E_{1_{(t)I}} > E_{2_{(t)I}}$ and $E_{1_{(t)I}} > E_{3_{(t)I}}$,

   $$\text{then } A_{CX_{1(t)I}} = \frac{2}{3}\left[\sum_{i=7}^{7} A_{TX_{i(t)I}} - \sum_{i=1}^{7} A_{SX_{i(t)I}}\right].$$

   If $E_{1_{(t)I}} \not> E_{2_{(t)I}}$ or $E_{1_{(t)I}} \not> E_{3_{(t)I}}$,

   then $A_{CX_{1(t)I}} = 0$ and $A_{TX_{1(t)I}} = A_{CX_{1(t)I}}$.

2. Barley ($A_{CX_{2(t)I}}$)

   a. For t=0: $A_{CX_{2(t)I}} = 2.09 - A_{SX_{2(t)I}}$

   b. For t=1,...,10:

   If $E_{2_{(t)I}} > E_{1_{(t)I}}$ and $E_{2_{(t)I}} > E_{3_{(t)I}}$,

   $$\text{then } A_{CX_{2(t)I}} = \frac{2}{3}\left[\sum_{i=1}^{7} A_{TX_{i(t)I}} - \sum_{i=1}^{7} A_{SX_{i(t)I}}\right].$$

   If $E_{2_{(t)I}} \not> E_{1(t)I}$ and $E_{2_{(t)I}} \not> E_{3_{(t)I}}$,

   then $A_{CX_{2(t)I}} = 0$ and $A_{TX_{2(t)I}} = A_{CX_{2(t)I}}$.

3. Maize ($A_{CX_{3(t)I}}$)

a. For t=0: $A_{CX_{3(t)I}} = .29 - A_{SX_{3(t)I}}$

b. For t=1,...,10:

$$A_{CX_{3(t)I}} = \frac{1}{6}\left[\sum_{i=1}^{7} A_{TX_{i(t)I}} - \sum_{i=1}^{7} A_{X_{i(t)I}}\right].$$

4. Teff ($A_{CX_{4(t)I}}$)

a. For t=0: $A_{CX_{4(t)I}} = .27 - A_{SX_{3(t)I}}$

b. For t=1,...,10: $A_{CX_{4(t)I}} = A_{TX_{4(t)I}} - A_{SX_{4(t)I}}$

5. Flax ($A_{CX_{5(t)I}}$)

a. For t=0: $A_{CX_{5(t)I}} = .41 - A_{SX_{3(t)I}}$

b. For t=1,...,10:

If $E_{3_{(t)I}} > E_{1_{(t)I}}$ and $E_{3_{(t)I}} > E_{2_{(t)I}}$,

then $A_{CX_{5(t)I}} = \frac{2}{3}\left[\sum_{i=1}^{7} A_{TX_{i(t)I}} - \sum_{i=1}^{7} A_{SX_{i(t)I}}\right].$

If $E_{3_{(t)I}} \not> E_{1_{(t)I}}$ and $E_{3_{(t)I}} \not> E_{2_{(t)I}}$,

then $A_{CX_{5(t)I}} = 0$ and $A_{TX_{5(t)I}} = A_{SX_{5(t)I}}$.

6. Peas ($A_{CX_{6(t)I}}$)

a. For t = 0: $A_{CX_{6I}} = .10 - A_{SX_{6I}}$

b. For t=1,...,10: $A_{CX_{6I}} = A_{TX_{6I}} - A_{SX_{6I}}$

7. Beans ($A_{CX_{7(t)I}}$)

Tools and Equipment

In strategy I emphasis is placed on improved animal-powered tools and stronger oxen. In strategy II animal-powered tools are dispensed with and hired engine-powered equipment is used for harvesting the main cash crop and for all operations except weeding. Chilalo is a rugged area in which engine-powered technology may not be a feasible proposition for very hilly farms. This strategy is appropriate, however, since there are many farms on which the proposal is feasible and CADU Hire Service is already putting this form of agricultural power into operation to a limited extent.

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a. For t = 0: $A_{CX_{7(t)I}} = .92 - A_{SX_{7(t)I}}$

b. For t=1,...,10:

$$A_{CX_{7(t)I}} = \frac{1}{6}\left[\sum_{i=1}^{7} A_{TX_{i(t)I}} - \sum_{i=1}^{7} A_{SX_{i(t)I}}\right].$$

Strategy II

The algorithm in strategy II is identical in operation to that in strategy I. However, the equations which define the operating margin on the major cash crop (wheat, barley and flax) include machinery hire charges. Thus:

$$E_{1(t)II} = E_{1(t)I} + \sum_{i=30}^{34} (r_{X_{i(t)II}})(P_{X_{i(t)II}});$$

$$E_{2(t)II} = E_{2(t)I} + \sum_{i=30}^{34} (r_{X_{i(t)II}})(P_{X_{i(t)II}});$$

$$E_{3(t)II} = E_{3(t)I} + \sum_{i=30}^{34} (r_{X_{i(t)II}})(P_{X_{i(t)II}}).$$

Determination of the $A_{CX_{i(t)II}}$ follows the same procedure as in strategy I.

For the budget model details of tools and equipment in use are recorded in Table B.2(b). Locally-made hand tools, the local oxen plow, sledge and miscellaneous oxen equipment are on inventory in the initiating year. In strategy I it has been assumed that improved varieties of the necessary hand tools are available at a slightly higher cost. Important new equipment to be purchased through medium-term loan accommodation is a pair of improved oxen and a set of oxen equipment, including a simply constructed cart.[1] In strategy II only improved hand tools are necessary for cultivation; most field operations are to be performed by hired tractor equipment.

Grain Storage

Improved grain bins are to be introduced at the beginning of the operational period of the budget model (t=1) to replace the local grain cribs. A suitable type of bin, developed at the Alamaya Agricultural College (Haile Selassie I University), 1.7 meters diameter, 2.5 meters high, is constructed of corrugated circular zinc sheets with a flat metal top. The bin's capacity is about 14 quintals; the cost is $40.00 with an estimated depreciation of 5 per cent of the original cost per annum.

Subsistence and Cash Crop Yields and Areas

No crops are specifically designated as cash crops, relative market prices, yields and production costs determine the farmer's decision-making process. Despite the fact that case studies in the Digelu and Yeloma areas of Chilalo show barley to be the predominant cash crop,[2] it is anticipated that the area will tend to specialize in wheat production because wheat yields slightly more than barley and wheat prices are 75-100 per cent higher than barley prices.[3] The budget model shows a trend in this direction.

A considerable amount of agronomic experimentation has been carried out in this area. There is clear evidence

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[1]Kline, et al., op. cit., Pt. II, p. 280.

[2]Leander, op. cit., pp. 89-90.

[3]Chilalo Agricultural Development Unit, Results of Trials and Observations . . ., p. 8.

that improved cultivation practices increase crop yields significantly[1] and that a combination of improved varieties along with improved cultivation practices leads to substantial increases in yields.[2]

> . . . greatest change in farm output for the least cash cost and the highest return per dollar spent results from improved seed, plus associated improved cultural practices that cost little more than present farming methods. Introduction of other improved production inputs will usually cost more and return less per dollar spent. For example, fertilizer will not normally return as much per dollar spent as improved seed . . .[3]

Thus, the budget model includes proposals to use improved crop varieties along with improved cultivation techniques but excludes the use of fertilizers and sprays.

Assumptions for crop yields during the operational period (t=1,...,10) of the budget model are recorded in Table B.2(c). Two production levels have been used for each crop. The high production level assumes that farmers are able to reach the estimate of maximum attainable yields under commercial conditions in the 10 year period; the low level assumes half the maximum level is attained in the tenth year.

Crop rotation is important[4] and the cleaning facilities afforded by maize and beans render the combination of wheat or barley or flax with maize and beans an excellent cash crop combination. For the cash crop areas the year-to-year rotation has the following pattern:

```
 wheat   wheat           wheat   wheat
  or      or              or      or
barley--barley--beans--barley--barley--maize
  or      or              or      or
 flax    flax            flax    flax
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[1] *Ibid.*, pp. 52-60.

[2] Clarence J. Miller, *et al.*, *Production of Grains and Pulses . . .*, pp. 77-78.

[3] *Ibid.*, p. 78.

[4] *Ibid.*, p. 70.

Labor Utilization

The assumptions for labor requirements, shown in Table B.2(d), are crude estimates based on observations published by CADU.[1] The number of plowing operations has been maintained at the level already established in current practice: _teff_ receives the highest number to produce a fine tilth; flax is found to grow better after a single plowing.

In strategy I after the initial introduction of improved equipment and supervision of techniques (t=1) it has been assumed that some improvement in efficiency of operation takes place: by the fourth operational year of the budget model (t=4) plowing efficiency is double that of the initiating year and weeding efficiency has increased by about 12 per cent; by the fifth year (t=5) planting efficiency is double.

Machinery requirements and hire charges for strategy II are recorded in Table B.2(e). Where hand operations are retained the same labor utilization rates as in strategy I have been used.

Budgets

Outputs and Inputs

The previous discussion has established the basic assumptions from which the budgets have been prepared. Only the accounts for strategy I, high-level yields are presented in detail: Table B.3 contains the annual income accounts and Table B.4 contains the corresponding annual input accounts.

Summaries of these data for both production levels are presented in subsequent tables: annual crop areas and total annual production are contained in Table B.5; annual gross incomes are contained in Table B.6; annual distribution of labor utilization according to operation is contained in Table B.7; seed requirements are contained in Table B.8; the summary of annual total costs (excluding financial charges) is contained in Table B.9.

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[1]Bengtsson, _op. cit._, pp. 5-25, and Leander, _op. cit._, pp. 24-45.

TABLE B.2 Continued
d. Labor operational requirements for strategies I and II, budget model (t=0,...,10)

Crop	Number of operations at year indicated			Labor requirements for operations at indicated year														
	Plow	Weed		Plow (strategy I)					Plant (strategy I)			Weed (strategy I & II)					Harvest (strategy I)	Thresh & winnow (strategy I)
	0-10	0	1-10	0	1	2	3	4-10	0	1-4	5-10	0	1	2	3	4-10	0-10	0-10
				man-hours per hectare													man-hours/quintal	
Wheat	3	1	2	72.81	63.72	54.63	45.51	36.42	50.00	30.00	25.00	95.51	181.64	172.14	162.64	153.12	12.10	7.12
Barley	3	1	1	72.81	63.72	54.63	45.51	36.42	50.00	30.00	25.00	94.74	90.00	85.26	80.52	75.79	12.90	6.46
Maize	3	1	4	72.81	63.72	54.63	45.51	36.42	50.00	24.00	24.00	95.00	361.00	342.00	323.00	304.00	13.44	3.75
Teff	4	1	2	97.08	84.95	72.82	60.69	48.45	50.00	24.00	24.00	100.00	190.00	180.00	170.00	160.00	12.59	8.57
Flax	1	1	2	24.27	21.24	18.21	15.17	12.14	50.00	30.00	25.00	81.81	166.73	157.85	148.97	140.12	7.67	9.06
Peas	3	1	4	72.81	63.72	54.63	45.51	36.42	50.00	30.00	25.00	97.22	369.43	349.98	330.53	311.10	17.36	8.33
Beans	3	1	4	72.81	63.72	54.63	45.51	36.42	50.00	30.00	25.00	97.22	369.43	349.98	330.53	311.10	17.36	8.33

Source: Calculated from data contained in: Bengtsson, *op. cit.*, pp. 5-25, and Leander, *op. cit.*, pp. 24-45.

TABLE B.2 Continued
e. Machine operational requirements for strategy II, budget model (t=1,...,10)

Item	Machine rates and costs for operations								
	Plow[a]		Plant[b]		Disc cover[a]		Combine		
	Rate	Cost	Rate	Cost	Rate	Cost	Rate 1[a]	Rate 2[b]	Cost
	hrs./ha.	$/hr.	hrs./ha.	$/hr.	hrs./ha.	$/hr.	hrs./ha.	hrs./ha.	$/hr.
Tractor or combine costs	2.00	4.80	2.50	6.00	1.5	4.8	.8818	1.1758	12.00

[a]All land.

[b]All land except for pea and *teff* crops which are hand planted.

TABLE B.3 Chilalo: Annual income accounts, budget model (t=0,...,10)--strategy I, high-level yields, years 1-10

Year	Crop and other income	Area	Yield	Production	Non-cash product	Cash product and other cash income	Gross income
		hectares	q/ha.	-quintals-	--------------dollars[a]		-----------------
0	Wheat	1.58	9.0	12.80	10.90	100.70	111.60
	Barley	2.09	10.0	18.81	66.61	52.27	118.88
	Maize	.29	16.0	4.08	6.07	16.47	22.54
	Teff	.27	7.0	1.71	17.92	-	17.92
	Flax	.41	7.0	2.58	5.75	19.87	25.62
	Peas	.10	8.0	.73	5.78	-	5.78
	Beans	.36	8.0	2.59	4.38	11.17	15.55
	Other	-			-	12.45	12.45
	Total	5.10			117.42[a]	212.93	330.35[b]
		Strategy I: Years 1-10: High-level yields					
1	Wheat	1.99	15.9	30.65	18.14	249.10	267.24
	Barley	1.35	10.9	14.23	85.83	4.13	89.95
	Maize	.56	25.0	13.57	10.16	64.78	74.93
	Teff	.37	12.0	4.28	29.87	14.93	44.80
	Flax	.08	8.0	.65	5.75	.73	6.48
	Peas	.16	8.2	1.25	9.74	.12	9.86
	Beans	.60	8.8	5.11	7.38	23.30	30.68
	Other	-			-	12.44	12.44
	Total	5.10[a]			166.86	369.53	536.39
2	Wheat	2.70	19.8	51.87	18.14	434.17	452.31
	Barley	1.30	11.8	14.84	85.83	7.94	93.77
	Maize	.74	27.8	19.90	10.16	99.68	109.84
	Teff	.35	13.3	4.51	29.87	17.42	47.29
	Flax	.08	8.9	.72	5.75	1.36	7.11
	Peas	.15	8.4	1.26	9.74	.24	9.98
	Beans	.78	9.7	7.32	7.38	36.52	43.90
	Other	-			-	15.10	15.10
	Total	6.10			166.86	612.43	779.30
3	Wheat	3.09	23.8	71.31	18.14	603.64	621.78
	Barley	1.24	12.7	15.26	85.83	10.63	96.46
	Maize	.83	30.6	24.74	10.16	126.41	136.47
	Teff	.33	14.7	4.71	29.87	19.46	49.33
	Flax	.08	9.7	.77	5.75	1.89	7.65
	Peas	.15	8.6	1.27	9.74	.35	10.09
	Beans	.87	10.6	8.99	7.38	46.54	53.92
	Other	-			-	16.44	16.44
	Total	6.60			166.86	825.38	992.24
4	Wheat	3.14	27.8	84.57	18.14	719.30	737.44
	Barley	1.19	13.6	15.65	85.83	13.09	98.92
	Maize	.84	33.3	27.28	10.16	140.44	150.59
	Teff	.32	16.0	4.90	29.87	21.52	51.39
	Flax	.08	10.6	.83	5.75	2.49	8.24
	Peas	.15	8.8	1.29	9.74	.46	10.21
	Beans	.89	11.4	9.79	7.38	51.35	58.73
	Other	-			-	16.46	16.46
	Total	6.60			166.86	965.11	1,131.97

5	Wheat	3.18	31.7	97.67	18.14	833.57	851.71
	Barley	1.15	14.5	16.14	85.83	16.18	102.01
	Maize	.85	36.1	29.88	10.16	154.80	164.95
	Teff	.30	17.3	5.03	29.87	22.86	52.73
	Flax	.08	11.5	.89	5.75	3.07	8.82
	Peas	.15	9.0	1.30	9.74	.57	10.31
	Beans	.89	12.2	10.58	7.38	56.09	63.47
	Other	-			-	16.49	16.49
	Total	6.60			166.86	1,103.63	1,270.50
6	Wheat	3.21	33.1	103.18	18.14	881.60	899.73
	Barley	1.11	15.4	16.60	85.83	19.07	104.90
	Maize	.86	38.9	32.46	10.16	169.04	179.20
	Teff	.29	18.7	5.23	29.87	24.89	54.76
	Flax	.08	12.4	.95	5.75	3.63	9.38
	Peas	.15	9.2	1.32	9.74	.68	10.42
	Beans	.90	13.1	11.45	7.38	61.29	68.67
	Other	-			-	16.52	16.52
	Total	6.60			166.86	1,176.73	1,343.59
7	Wheat	3.25	34.5	108.91	18.14	931.57	949.70
	Barley	1.07	16.3	16.90	85.83	20.97	106.79
	Maize	.87	41.7	35.10	10.16	183.62	193.78
	Teff	.28	20.0	5.38	29.87	26.49	56.35
	Flax	.08	13.3	1.00	5.75	4.18	9.94
	Peas	.15	9.4	1.33	9.74	.78	10.53
	Beans	.91	14.0	12.34	7.38	66.63	74.01
	Other	-			-	16.54	16.54
	Total	6.61			166.86	1,250.78	1,417.65
8	Wheat	3.29	35.4	113.09	18.14	968.05	986.19
	Barley	1.03	17.2	17.17	85.83	22.72	108.54
	Maize	.88	44.4	37.71	10.16	198.03	208.19
	Teff	.27	21.3	5.47	29.87	27.45	57.31
	Flax	.08	14.2	1.06	5.75	4.72	10.47
	Peas	.14	9.6	1.34	9.74	.89	10.63
	Beans	.92	14.8	13.15	7.38	71.51	78.89
	Other	-			-	16.57	16.57
	Total	6.61			166.86	1,309.92	1,476.79
9	Wheat	3.32	37.2	119.93	18.14	1,027.67	1,045.81
	Barley	1.00	18.1	17.56	85.83	25.13	110.96
	Maize	.88	47.2	40.35	10.16	212.60	222.76
	Teff	.26	22.6	5.60	29.87	28.83	58.70
	Flax	.08	15.1	1.11	5.75	5.24	11.00
	Peas	.14	9.8	1.35	9.74	.99	10.73
	Beans	.92	15.6	13.94	7.38	76.26	83.64
	Other	-			-	16.59	16.59
	Total	6.60			166.86	1,393.32	1,560.18
10	Wheat	3.36	38.6	125.73	18.14	1,078.23	1,096.37
	Barley	.97	19.0	17.79	85.83	26.64	112.46
	Maize	.89	50.0	43.08	10.16	227.66	237.82
	Teff	.24	24.0	5.70	29.87	29.87	59.74
	Flax	.07	16.0	1.16	5.75	5.75	11.50
	Peas	.14	10.0	1.37	9.74	1.08	10.82
	Beans	.93	16.5	14.85	7.38	81.71	89.09
	Other	-			-	16.61	16.61
	Total	6.60			166.86	1,467.55	1,634.41

[a] U.S. dollars.

[b] Small errors in additions are due to calculated values being rounded to 2 decimal places.

TABLE B.4 Chilalo: Annual input accounts, budget model (t=0,...,10)--strategy I, high-level yields, years 1-10

Year	Crop	Labor		Seed		Sacks	Rent	Depreciation		Total inputs		
		Non-cash	Cash	Non-cash	Cash	Cash	Cash	Non-cash	Cash	Non-cash	Cash	Total
		--------dollars[a]--------										
0	Wheat	17.91	13.00	14.90	-	1.42	39.10	3.72	3.39	36.53	56.91	93.44
	Barley	24.90	18.07	13.58	-	2.09	51.72	4.92	4.49	43.40	76.37	119.77
	Maize	4.14	3.01	.70	-	.46	7.18	.68	.62	5.52	11.27	16.79
	Teff	3.11	2.25	1.33	-	.19	6.68	.64	.58	5.08	9.70	14.78
	Flax	3.25	2.35	4.55	-	.29	10.15	.96	.88	8.76	13.67	22.43
	Peas	1.24	.91	.69	-	.08	2.47	.23	.22	2.17	3.68	5.85
	Beans	4.44	3.22	1.61	-	.29	8.90	.85	.77	6.90	13.18	20.08
	Total	59.00	42.81	37.36	-	4.82	126.20	12.00	10.95	108.36	184.78	293.14
		Strategy I Years 1-10: High-level yield										
1	Wheat	43.36	14.36	-	19.87	3.16	81.01	-	26.30	43.36	144.70	188.06
	Barley	19.96	6.61	-	10.77	1.46	21.95	-	17.84	19.96	91.63	111.59
	Maize	18.47	6.12	-	1.01	1.40	22.80	-	7.40	18.47	38.73	57.20
	Teff	7.63	2.53	-	1.23	.44	15.06	-	4.89	7.63	24.15	31.78
	Flax	1.11	.37	-	.38	.07	3.26	-	1.06	1.11	5.14	6.25
	Peas	3.96	1.31	-	.85	.13	6.51	-	2.12	3.96	10.92	14.88
	Beans	15.51	5.13	-	3.23	.53	24.42	-	7.93	15.51	41.24	56.75
	Total	110.00	36.43	-	37.33[b]	7.19	208.01	-	67.54	110.00	356.49[b]	466.49[b]
2	Wheat	50.39	35.68	-	27.01	5.35	134.29	-	29.89	50.39	232.22	282.61
	Barley	15.12	10.70	-	10.37	1.53	64.66	-	14.39	15.12	101.65	116.77
	Maize	19.41	13.74	-	1.33	2.05	36.80	-	8.19	19.41	62.11	81.52
	Teff	5.72	4.05	-	1.17	.47	17.41	-	3.88	5.72	26.98	32.70
	Flax	.86	.61	-	.37	.07	3.98	-	.89	.86	5.92	6.78
	Peas	2.94	2.08	-	.84	.13	7.46	-	1.66	2.94	12.17	15.11
	Beans	15.57	11.02	-	4.20	.75	38.79	-	8.64	15.57	63.40	78.97
	Total	100.00	77.88	-	45.28	10.35	303.39	-	67.54	110.00	504.45	614.45
3	Wheat	54.75	52.67	-	30.89	7.35	181.64	-	31.68	54.75	304.23	358.98
	Barley	12.69	12.21	-	9.91	1.57	72.89	-	12.72	12.69	109.30	121.99
	Maize	19.51	18.77	-	1.50	2.55	48.79	-	8.50	19.51	80.11	99.62
	Teff	4.76	4.58	-	1.10	.49	19.40	-	3.38	4.76	28.95	33.71
	Flax	.74	.72	-	.37	.08	4.71	-	.81	.74	6.69	7.43
	Peas	2.44	2.35	-	.82	.13	8.82	-	1.54	2.44	13.66	16.10
	Beans	15.11	14.54	-	4.72	.93	51.14	-	8.91	15.11	80.24	95.35
	Total	110.00	105.83	-	49.32	13.10	387.39	-	67.54	110.00	623.18	733.18
4	Wheat	57.40	60.81	-	31.36	8.72	210.37	-	32.09	57.40	343.35	400.75
	Barley	11.68	12.37	-	9.49	1.61	79.73	-	12.16	11.68	115.36	127.04
	Maize	19.21	20.35	-	1.52	2.81	56.28	-	8.58	19.21	89.54	108.75
	Teff	4.38	4.64	-	1.06	.51	21.44	-	3.27	4.38	30.92	35.30
	Flax	.71	.75	-	.36	.09	5.36	-	.82	.71	7.38	8.09
	Peas	2.21	2.34	-	.82	.13	10.05	-	1.53	2.21	14.87	17.08
	Beans	14.41	15.26	-	4.78	1.01	59.63	-	9.09	14.41	89.77	104.18
	Total	110.00	116.53	-	49.39	14.88	442.86	-	67.54	110.00	691.19	801.19
5	Wheat	59.36	71.48	-	31.76	10.07	239.86	-	32.54	59.36	385.71	445.07
	Barley	10.88	13.10	-	9.18	1.66	86.74	-	11.77	10.88	122.45	133.33
	Maize	19.07	22.96	-	1.54	3.08	64.15	-	8.70	19.07	100.43	119.50
	Teff	4.07	4.90	-	1.00	.53	22.62	-	3.07	4.07	32.12	36.19
	Flax	.67	.81	-	.36	.09	6.03	-	.82	.67	8.11	8.78
	Peas	2.04	2.46	-	.81	.13	11.31	-	1.53	2.04	16.24	18.28
	Beans	13.91	16.75	-	4.83	1.09	67.13	-	9.11	13.91	98.91	112.82
	Total	110.00	132.46	-	49.48	16.65	497.84	-	67.54	110.00	763.96	873.96

6	Wheat	59.60	77.10	-	32.14	10.63	256.24	-	32.85	59.60	408.96	468.56
	Barley	10.54	13.64	-	8.89	1.71	88.61	-	11.36	10.54	124.21	134.75
	Maize	19.38	25.07	-	1.55	3.35	68.65	-	8.80	19.38	107.42	126.80
	Teff	3.94	5.10	-	.96	.54	23.15	-	2.97	3.94	32.72	36.66
	Flax	.66	.85	-	.35	.10	6.39	-	.82	.66	8.51	9.17
	Peas	1.96	2.53	-	.80	.14	11.97	-	1.53	1.96	16.97	18.93
	Beans	13.92	18.01	-	4.86	1.18	71.84	-	9.21	13.92	105.10	119.02
	Total	110.00	142.31	-	49.55	17.65	526.85	-	67.54	110.00	803.89	913.89
7	Wheat	59.89	82.92	-	32.54	11.23	273.49	-	33.21	59.89	433.39	493.28
	Barley	10.15	14.05	-	8.55	1.74	90.04	-	10.93	10.15	125.31	135.46
	Maize	19.68	27.24	-	1.56	3.62	73.21	-	8.89	19.68	114.52	134.20
	Teff	3.81	5.28	-	.93	.55	23.56	-	2.86	3.81	33.18	36.99
	Flax	.65	.90	-	.35	.10	6.73	-	.82	.65	8.90	9.55
	Peas	1.88	2.60	-	.79	.14	12.62	-	1.53	1.88	17.68	19.56
	Beans	13.95	19.31	-	4.91	1.28	76.58	-	9.30	13.95	111.38	125.33
	Total	110.00	152.29	-	49.63	18.66	556.24	-	67.54	110.00	844.35	954.35
8	Wheat	59.93	87.45	-	32.94	11.66	288.98	-	33.67	59.93	454.70	514.63
	Barley	9.84	14.36	-	8.23	1.77	90.47	-	10.54	9.84	125.37	135.21
	Maize	20.08	29.30	-	1.58	3.89	77.29	-	9.01	20.08	121.08	141.16
	Teff	3.68	5.37	-	.89	.56	22.84	-	2.66	3.68	32.32	36.00
	Flax	.65	.94	-	1.34	.11	7.02	-	.82	.65	9.23	9.88
	Peas	1.81	2.65	-	.77	.14	12.30	-	1.43	1.81	17.29	19.10
	Beans	14.02	20.45	-	4.95	1.35	80.81	-	9.41	14.02	116.97	130.99
	Total	110.00	160.52	-	49.70	19.48	579.71	-	67.54	110.00	876.95	986.95
9	Wheat	60.37	94.10	-	33.24	12.36	308.26	-	33.98	60.37	481.94	542.31
	Barley	9.53	14.85	-	8.00	1.81	92.85	-	10.23	9.53	127.74	137.25
	Maize	20.25	31.57	-	1.59	4.16	81.71	-	9.00	20.25	128.03	148.28
	Teff	3.55	5.53	-	.85	.58	24.14	-	2.66	3.55	33.76	37.31
	Flax	.64	.99	-	.34	.11	7.43	-	.82	.64	9.69	10.33
	Peas	1.74	2.71	-	.77	.14	13.00	-	1.43	1.74	18.05	19.79
	Beans	13.92	21.70	-	4.97	1.44	85.42	-	9.42	13.92	122.95	136.87
	Total	110.00	171.44	-	49.76	20.60	612.81	-	67.54	110.00	922.15	1,032.15
10	Wheat	60.61	99.97	-	33.58	12.96	326.98	-	34.38	60.61	507.87	568.48
	Barley	9.20	15.18	-	7.72	1.83	94.39	-	9.92	9.20	129.04	138.24
	Maize	20.52	33.84	-	1.60	4.44	86.61	-	9.11	20.52	135.60	156.12
	Teff	3.42	5.64	-	.82	.59	23.36	-	2.46	3.42	32.87	36.29
	Flax	.63	1.04	-	.34	.13	6.81	-	.72	.63	9.04	9.67
	Peas	1.67	2.76	-	.76	.14	13.62	-	1.43	1.67	18.71	20.38
	Beans	13.94	23.00	-	5.01	1.53	90.50	-	9.52	13.94	129.56	143.50
	Total	110.00	181.43	-	49.83	21.62	642.27	-	67.54	110.00	962.68	1,072.68

[a]U.S. dollars.

[b]Small errors in addition are due to calculated values being rounded to two decimal places.

TABLE B.5 Chilalo: Annual crop areas, and summary of annual total production, budget model (t=0,...,10)

Crop	Item	Yield level[a]	Units	0	1	2	3	4	5	6	7	8	9	10
				Crop areas and total production at indicated year										
								Strategy I Years 1-10						
Wheat	Area	H,L	hectares	1.58	1.99	2.70	3.09	3.14	3.18	3.21	3.25	3.29	3.32	3.36
	Total production	H	quintals	12.80	30.65	51.87	71.31	84.57	97.67	103.18	108.91	113.09	119.93	125.73
		L	quintals		20.43	31.17	39.55	44.41	48.99	52.06	54.93	58.14	61.26	64.49
Barley	Area	H,L	hectares	2.09	1.35	1.30	1.24	1.19	1.15	1.11	1.07	1.03	1.00	.97
	Total production	H	quintals	18.81	14.23	14.84	15.26	15.65	16.14	16.60	16.90	17.17	17.56	17.79
		L	quintals		13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
Maize	Area	H,L	hectares	.29	.56	.74	.83	.84	.85	.86	.87	.88	.88	.89
	Total production	H	quintals	4.08	13.57	19.90	24.74	27.28	29.88	32.40	35.10	37.71	40.35	43.08
		L	quintals		9.07	12.60	15.04	15.98	16.89	17.78	18.77	19.71	20.60	21.54
Teff	Area	H,L	hectares	.27	.37	.35	.33	.32	.30	.29	.28	.26	.26	.24
	Total production	H	quintals	1.71	4.28	4.51	4.71	4.90	5.03	5.23	5.38	5.47	5.60	5.70
		L	quintals		2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
Linseed	Area	H,L	hectares	.41	.08	.08	.08	.08	.08	.08	.08	.08	.08	.07
	Total production	H	quintals	2.58	.65	.72	.77	.83	.89	.95	1.00	1.06	1.11	1.16
		L	quintals		.58	.58	.58	.58	.58	.58	.58	.58	.58	.58
Peas	Area	H,L	hectares	.10	.16	.15	.15	.15	.15	.15	.15	.14	.14	.14
	Total production	H	quintals	.73	1.25	1.26	1.27	1.29	1.30	1.32	1.33	1.34	1.35	1.37
		L	quintals		1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
Beans	Area	H,L	hectares	.36	.60	.78	.87	.89	.89	.90	.91	.92	.92	.93
	Total production	H	quintals	2.59	5.11	7.32	8.99	9.79	10.58	11.45	12.34	13.15	13.94	14.85
		L	quintals		4.82	6.49	7.55	7.90	8.24	8.56	8.90	9.24	9.56	9.90
All crops	<u>Area</u>: Subsistence	H	hectares	1.97	2.97	1.94	1.78	1.66	1.55	1.47	1.38	1.32	1.25	1.21
	Cash crops	H	hectares	3.13	2.04	4.16	4.82	4.95	5.05	5.13	5.23	5.28	5.35	5.39
	Total	H	hectares	5.10	5.10	6.10	6.60	6.61	6.60	6.60	6.61	6.60	6.60	6.60
	Subsistence	L	hectares	1.96	2.42	2.32	2.21	2.12	2.04	1.97	1.90	1.84	1.78	1.73
	Cash crops	L	hectares	3.14	2.68	3.78	4.39	4.48	4.56	7.33	4.70	4.76	4.82	4.87
	Total	L	hectares	5.10	5.10	6.10	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
								Strategy II Years 1-10						
Wheat	Area	H,L	hectares	1.58	2.56	3.26	3.96	3.98	4.01	4.03	4.05	4.07	4.09	4.11
	Total production	H	quintals	12.80	39.54	62.56	91.31	107.39	123.18	129.31	135.57	139.88	147.63	153.93
		L	quintals		26.36	37.60	50.64	56.40	61.78	65.24	88.37	71.92	75.40	78.96
Barley	Area	H,L	hectares	2.09	.70	.68	.65	.62	.60	.58	.56	.54	.52	.51
	Total production	H	quintals	18.81	7.45	7.77	7.99	8.19	8.45	8.69	8.85	8.99	9.19	9.32
		L	quintals		7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
Maize	Area	H,L	hectares	.29	.68	.86	1.03	1.04	1.04	1.05	1.05	1.05	1.06	1.06
	Total production	H	quintals	4.08	16.57	23.09	30.57	33.47	36.46	39.44	42.44	45.37	48.38	51.44
		L	quintals		11.07	14.62	18.58	19.60	20.60	21.59	22.69	23.71	24.70	25.10
Teff	Area	H,L	hectares	.27	.25	.24	.22	.21	.20	.20	.19	.18	.17	.17
	Total production	H	quintals	1.71	2.90	3.06	3.19	3.32	3.41	3.54	3.64	3.70	3.79	3.86
		L	quintals		1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93
Linseed	Area	H,L	hectares	.41	.08	.08	.08	.08	.08	.08	.08	.08	.08	.07
	Total production	H	quintals	2.58	.65	.72	.77	.83	.89	.95	1.00	1.06	1.11	1.16
		L	quintals		.58	.58	.58	.58	.58	.58	.58	.58	.58	.58
Peas	Area	H,L	hectares	.10	.11	.10	.10	.10	.10	.10	.10	.10	.10	.10
	Total production	H	quintals	.73	.84	.85	.86	.87	.88	.89	.90	.91	.91	.92
		L	quintals		.83	.83	.83	.83	.83	.83	.83	.83	.83	.83
Beans	Area	H,L	hectares	.36	.71	.88	1.06	1.06	1.07	1.07	1.08	1.08	1.08	1.09
	Total production	H	quintals	2.59	6.06	.31	10.87	11.76	12.65	13.63	14.62	15.51	16.40	17.40
		L	quintals		5.71	7.37	9.13	9.49	9.85	10.19	10.55	10.90	11.25	11.60
All crops	<u>Area</u>: Subsistence	H	hectares	1.97	1.26	1.15	1.06	.98	.92	.87	.82	.78	.74	.71
	Cash crops	H	hectares	3.13	3.84	4.95	6.04	6.12	6.18	6.23	6.28	6.32	6.36	6.39
	Total	H	hectares	5.10	5.10	6.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10
	Subsistence	L	hectares	1.97	2.11	1.93	1.33	1.28	1.23	1.19	1.15	1.11	1.08	1.04
	Cash crops	L	hectares	3.13	2.99	4.17	5.77	5.82	5.87	5.91	5.95	5.99	6.02	6.06
	Total	L	hectares	5.10	5.10	6.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10

[a] Waste allowance: t=0, 10 per cent; t=1,...,10, 3 per cent.

TABLE B.6 Chilalo: Summary of annual gross incomes, budget model (t=0,...,10)

Income	Crop	Annual gross incomes at indicated year 0	1	2	3	4	5	6	7	8	9	10
		dollars[a]										
		Strategy I Years 1-10: High-level yields										
Non-cash	Food & cash	117.42	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86
Cash	Cash	200.47	357.08	597.34	808.94	948.65	1,087.14	1,160.21	1,234.24	1,293.36	1,376.73	1,450.94
Other	-	12.45	12.44	15.09	16.44	16.46	16.49	16.52	16.54	16.57	16.59	16.61
Total		330.35	536.39	779.30	992.24	1,131.97	1,270.50	1,343.59	1,417.65	1,476.79	1,560.18	1,634.41
		Strategy I Years 1-10: Low-level yields										
Non-cash	Food & cash		166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86
Cash	Cash		221.47	344.63	437.47	487.19	534.16	567.77	600.33	635.56	669.58	705.01
Other	-		12.44	15.09	16.44	16.46	16.49	16.52	16.54	16.57	16.59	16.61
Total			400.78	526.59	620.77	670.52	717.52	751.15	783.73	818.99	853.03	888.48
		Strategy II Years 1-10: High-level yields										
Non-cash	Food & cash		101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61
Cash	Cash		461.56	716.23	1,027.00	1,191.85	1,354.52	1,433.85	1,513.62	1,574.99	1,667.23	1,747.12
Other	-		12.71	15.35	17.99	18.01	18.03	18.05	18.07	18.08	18.10	18.11
Total			575.87	833.19	1,148.60	1,311.47	1,474.16	1,553.50	1,633.30	1,694.68	1,786.94	1,866.84
		Strategy II Years 1-10: Low-level yields										
Non-cash	Food & cash		101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61
Cash	Cash		301.11	428.66	574.85	832.81	687.44	725.14	760.65	799.27	837.22	875.96
Other	-		12.71	15.35	17.99	18.01	18.03	18.05	18.07	18.08	18.10	18.11
Total			415.43	545.62	694.45	752.43	807.08	844.80	880.32	918.97	956.93	995.68

[a]U.S. dollars. [b]Small errors due to rounding.

TABLE B.7 Chilalo: Annual labor use in field operations, budget model (t=0,...,10)

Operation	Annual field labor requirements at indicated year 0	1	2	3	4	5	6	7	8	9	10
	man-hours										
	Strategy I Years 1-10: High-level yields										
Plowing	358	329	337	303	242	242	242	242	242	242	242
Seeding	255	148	176	191	191	164	164	164	164	164	164
Weeding	482	1,047	1,230	1,279	1,211	1,216	1,221	1,226	1,231	1,235	1,240
Harvesting	614	934	1,338	1,686	1,910	2,132	2,261	2,392	2,500	2,644	2,775
Threshing/winnowing	327	471	677	858	977	1,095	1,158	1,222	1,273	1,344	1,408
Total	2,036	2,929	3,758	4,317	4,531	4,849	5,046	5,246	5,410	5,629	5,829
	Strategy I Years 1-10: Low-level yields										
Plowing		329	337	303	242	242	242	242	242	242	242
Seeding		148	176	191	191	164	164	164	164	164	164
Weeding		1,046	1,230	1,279	1,211	1,216	1,221	1,226	1,231	1,235	1,239
Harvesting		711	924	1,081	1,161	1,237	1,293	1,349	1,408	1,465	1,524
Threshing/winnowing		358	465	545	587	627	656	684	714	743	773
Total		2,592	3,132	3,399	3,392	3,486	3,576	3,665	3,759	3,849	3,942
	Strategy II Years 1-10: High-level yields										
Plowing		-	-	-	-	-	-	-	-	-	-
Seeding		9	9	8	8	7	7	7	7	7	6
Weeding		1,138	1,313	1,462	1,380	1,383	1,385	1,388	1,391	1,393	1,395
Harvesting		495	633	787	848	911	975	1,039	1,098	1,160	1,224
Threshing/winnowing		205	253	308	330	352	375	398	419	441	463
Total		1,847	2,208	2,565	2,566	2,653	2,742	2,831	2,915	3,001	3,088
	Strategy II Years 1-10: Low-level yields										
Plowing		-	-	-	-	-	-	-	-	-	-
Seeding		9	9	8	8	7	7	7	7	7	6
Weeding		1,137	1,313	1,462	1,380	1,383	1,385	1,388	1,391	1,393	1,395
Harvesting		394	473	560	581	601	621	642	662	682	703
Threshing/winnowing		169	197	227	234	241	248	255	262	269	276
Total		1,709	1,992	2,257	2,203	2,232	2,261	2,292	2,322	2,351	2,380

TABLE B.8 Chilalo: Inputs of seeds, budget model (t=0,...,10)

Crop	Seed price at indicated year		Seed rate at indicated year	
	0	1-10	0	1-10
	---------$/q.---------		--------q/ha.----------	
Wheat	8.20	10.00	1.15	1.00
Barley	5.60	8.00	1.16	1.00
Maize	4.00	6.00	.60	.30
Teff	9.80	15.20	.50	.22
Flax	15.00	18.00	.74	.25
Peas	5.20	6.00	1.31	.90
Beans	5.00	6.00	.90	.90

TABLE B.9 Chilalo: Summary of annual total costs for inputs (excluding financial charges), budget model (t=0,...,10)

Year	Labor		Seed		Sacks	Rent	Depreciation		Total inputs		
	Non-cash	Cash	Non-cash	Cash	Cash	Cash	Non-cash	Cash	Non-cash	Cash	Total
	---------------					dollars[a]					---------------
0	59.00	42.81	37.36	-	4.82	126.20	12.00	10.95	108.36	184.78	293.14
	Strategy I Years 1-10: High-level yields										
1	110.00	36.43	-	37.33	7.19	208.01	-	67.54	110.00	356.49[b]	466.49[b]
2	110.00	77.88	-	45.28	10.35	303.39	-	67.54	110.00	504.45	614.45
3	110.00	105.83	-	49.32	13.10	387.39	-	67.54	110.00	623.18	733.18
4	110.00	116.53	-	49.39	14.88	442.86	-	67.54	110.00	691.19	801.19
5	110.00	132.46	-	49.48	16.65	497.84	-	67.54	110.00	763.96	873.96
6	110.00	142.31	-	49.55	17.65	526.85	-	67.54	110.00	803.89	913.89
7	110.00	152.29	-	49.63	18.66	556.24	-	67.54	110.00	844.35	954.35
8	110.00	160.52	-	49.70	19.48	579.71	-	67.54	110.00	876.95	986.95
9	110.00	171.44	-	49.76	20.60	612.81	-	67.54	110.00	922.15	1,032.15
10	110.00	181.43	-	49.83	21.62	642.27	-	67.54	110.00	962.68	1,072.68
	Strategy I Years 1-10: Low-level yields										
1	110.00	19.58	-	37.33	5.42	154.17	-	67.54	110.00	284.04	394.04
2	110.00	45.59	-	45.28	7.06	203.06	-	67.54	110.00	369.53	479.53
3	110.00	59.94	-	49.32	8.29	239.92	-	67.54	110.00	424.99	534.99
4	110.00	59.63	-	49.39	8.92	259.66	-	67.54	110.00	445.13	555.13
5	110.00	64.31	-	49.48	9.52	278.31	-	67.54	110.00	469.15	579.15
6	110.00	68.80	-	49.55	9.96	291.65	-	67.54	110.00	487.49	597.49
7	110.00	73.23	-	49.63	10.40	304.56	-	67.54	110.00	505.36	615.36
8	110.00	77.94	-	49.70	10.86	318.56	-	67.54	110.00	524.60	634.60
9	110.00	82.24	-	49.76	11.31	332.07	-	67.54	110.00	543.10	653.10
10	110.00	87.12	-	49.83	11.77	346.13	-	67.54	110.00	562.39	672.39

Year	Labor		Seed		Sacks	Rent	Depreciation		Hire charges	Total inputs		
	Non-cash	Cash	Non-cash	Cash	Cash	Cash	Non-cash	Cash	Cash	Non-cash	Cash	Total
	---------------						dollars[a]					---------------
	Strategy II Years 1-10: High-level yields											
1	55.00	37.34	-	38.12	7.63	223.58	-	6.60	207.13	55.00	497.71	549.71
2	55.00	55.38	-	46.04	10.96	324.68	-	6.60	220.87	55.00	664.55	719.55
3	55.00	73.27	-	53.98	15.01	448.06	-	6.60	260.38	55.00	857.30	912.30
4	55.00	73.31	-	54.03	17.10	513.50	-	6.60	260.91	55.00	925.45	980.45
5	55.00	77.65	-	54.09	19.17	578.08	-	6.60	261.43	55.00	997.02	1,052.02
6	55.00	82.14	-	54.14	20.25	609.58	-	6.60	261.86	55.00	1,034.57	1,089.57
7	55.00	86.57	-	54.20	21.34	641.25	-	6.60	262.30	55.00	107.25	1,127.25
8	55.00	90.75	-	54.25	22.21	665.61	-	6.60	262.75	55.00	1,102.16	1,157.16
9	55.00	95.02	-	54.29	23.44	702.23	-	6.60	277.53	55.00	1,159.12	1,214.12
10	55.00	99.42	-	54.34	24.54	733.95	-	6.60	277.99	55.00	1,196.84	1,251.84
	Strategy II Years 1-10: Low-level yields											
1	55.00	30.47	-	38.12	5.52	159.88	-	6.60	181.44	55.00	422.03	477.03
2	55.00	44.60	-	46.04	7.22	210.52	-	6.60	220.87	55.00	535.85	590.85
3	55.00	57.88	-	53.98	9.16	268.55	-	6.60	260.38	55.00	656.55	711.55
4	55.00	55.15	-	54.03	9.89	291.56	-	6.60	260.91	55.00	678.14	733.14
5	55.00	56.61	-	54.09	10.59	313.25	-	6.60	261.43	55.00	702.57	757.57
6	55.00	58.06	-	54.14	11.08	328.22	-	6.60	261.86	55.00	719.96	775.96
7	55.00	59.63	-	54.20	11.55	342.32	-	6.60	262.30	55.00	736.59	791.59
8	55.00	61.12	-	54.25	12.06	357.65	-	6.60	262.75	55.00	754.43	809.43
9	55.00	62.54	-	54.29	12.56	372.72	-	6.60	263.10	55.00	771.81	826.81
10	55.00	64.02	-	54.34	13.06	388.10	-	6.60	263.49	55.00	789.61	844.61

[a]U.S. dollars. [b]Small errors due to rounding.

Financial Costs

Financial costs are less complicated in this case than in the case of Agnale. There is no long-term investment (such as tree crops) in which productive returns are delayed for a number of years after having made the initial investment.

An assumption has been made that a short-term crop loan can be arranged to finance operating costs until the proceeds from harvest are available to meet these expenses. This arrangement is to be made at an interest rate of 8 per cent per annum charged on a monthly basis. Repayment of the crop loan is made at the end of each February following harvest in December and January. Costs of plowing, planting, seeds, weeding, and harvesting are all covered by the crop loan.

Medium-term loan accommodation is to be arranged to cover costs of purchasing tools and equipment. Repayment of principal with interest has been amortized at 7 per cent per annum over a period of seven years with the exception of the costs for oxen. Loans for the purchase of oxen are to be repaid over six years since this period is the maximum estimate for their working life.

Additional bank accommodation has also been arranged to cover animal losses. A negative cash margin for any year has been accommodated on overdraft terms (short-term loans) at 7 per cent per annum carried forward into the following year as a financial charge.

Depreciation on tools and equipment is a legitimate operating cost and has been charged in the input accounts. However, since the purchase of equipment has been funded from loans, the accumulated depreciation account has been used as a cash fund toward the payment of outstanding charges on the loan account. Details of financial charges and net financial costs are set out in Table B.10.

Budget Summary

The accounts of the budget model are summarized in Table B.11. In this case the individual farmer is assessed a land tax which has been charged at a rate of $1.68 per hectare.[1] Net income is recorded in the table before and after taxation.

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[1] Leander, op. cit., pp. 76, 79.

TABLE B.10 Chilalo: Annual financial charges and net financial costs, budget model (t=0,...,10)

Item	0	1	2	3	4	5	6	7	8	9	10
	Annual financial charges and costs at indicated year										
	dollars[a]										
Strategy I Years 1-10: High-level yields											
Crop loan	-	4.11	5.08	5.61	5.68	5.87	5.97	6.08	6.17	6.29	6.40
Overdraft	-	-	47.71	-	-	-	-	-	-	-	-
Medium term loan	-	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64
Total	-	110.75	159.43	112.25	112.32	112.51	112.61	112.72	112.81	112.93	113.04
Less depreciation fund	-	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54
Net financial costs	-	43.21	91.89	44.71	44.78	44.97	45.07	45.18	45.27	45.39	45.50
Strategy I Years 1-10: Low-level yields											
Crop loan		3.94	4.76	5.15	5.11	5.19	5.24	5.29	5.35	5.40	5.45
Overdraft		-	115.11	196.02	241.58	258.61	252.32	229.29	188.95	128.71	47.67
Medium term loan		106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64
Total		110.58	226.51	307.81	353.33	370.44	364.20	341.22	300.94	240.75	159.76
Less depreciation fund		67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54
Net financial costs		43.04	158.97	240.27	285.79	302.90	296.66	273.68	233.40	173.21	92.22
Strategy II Years 1-10: High-level yields											
Crop loan		3.92	4.67	5.39	5.31	5.36	5.41	5.46	5.50	5.55	5.60
Overdraft		-	54.30	19.59	-	-	-	-	-	-	-
Medium term loan		18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56
Total		22.48	77.53	43.54	23.87	23.92	23.97	24.02	24.06	24.11	24.16
Less depreciation fund		6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
Net financial costs		15.88	70.92[b]	36.93	17.26	17.31	17.36	17.41	17.46	17.51	17.55
Strategy II Years 1-10: Low-level yields											
Crop loan		3.85	4.56	5.23	5.12	5.15	5.17	5.19	5.21	5.23	5.24
Overdraft		-	148.13	289.87	412.15	503.93	569.83	618.61	650.61	662.61	653.44
Medium term loan		18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56
Total		22.41	171.25	313.66	435.83	527.64	593.56	642.36	674.38	686.40	677.24
Less depreciation fund		6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
Net financial costs		15.81	164.65	307.06	429.23	521.03	586.95	635.75	667.77	679.79	670.64

[a] U.S. dollars

[b] Small errors due to rounding.

TABLE B.11 Chilalo: Summary of budget model accounts (t=0,...,10)

Item	Annual account summary at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
Strategy I Years 1-10: High-level yields											
Gross income	330.35	536.39	779.30	992.24	1,131.97	1,270.50	1,343.59	1,417.65	1,476.79	1,560.18	1,634.41
less total costs[b]	293.14	466.49	614.45	733.18	801.19	873.96	913.89	954.35	986.95	1,032.15	1,072.68
Net returns	37.21	69.90	164.85	259.06	330.78	396.54	429.70	463.30	489.84	528.03	561.73
less net financial costs	-	43.21	91.89	44.71	44.78	44.97	45.07	45.18	45.27	45.39	45.50
Net income before taxes	37.21	26.69	72.96	214.35	286.00	351.57	384.63	418.12	444.57	482.64	516.23
less taxes	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes	22.79	12.27	58.54	199.93	271.58	337.15	370.21	403.70	430.15	468.22	501.81
Strategy I Years 1-10: Low-level yields											
Gross income		400.78	526.59	620.77	670.52	717.52	751.15	783.73	818.99	853.03	888.48
less total costs[b]		394.04	479.53	534.99	555.13	579.15	597.49	615.36	634.60	653.10	672.39
Net returns		6.74	47.05[c]	85.77	115.39	138.36	153.65	168.37	184.39	199.94	216.09
less net financial costs		43.04	158.97	240.27	285.79	302.90	296.66	273.68	233.40	173.21	92.22
Net income before taxes		-36.30	-111.92	-154.50	-170.40	-164.54	-143.01	-105.31	-49.01	26.73	123.87
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-50.72	-126.34	-168.92	-184.82	-178.96	-147.43	-119.73	-63.43	12.31	109.45
Strategy II Years 1-10: High-level yields											
Gross income		575.87	833.19	1,146.60	1,311.47	1,474.16	1,553.50	1,633.30	1,694.68	1,786.94	1,866.84
less total costs[b]		549.71	719.55	912.30	980.45	1,052.02	1,089.57	1,127.25	1,157.16	1,214.12	1,251.84
Net returns		26.16	113.64	234.30	331.02	422.14	463.93	506.05	537.52	572.82	615.00
less net financial costs		15.88	70.92	36.93	17.26	17.31	17.36	17.41	17.46	17.51	17.55
Net income before taxes		10.28	42.72	197.37	313.76	404.83	446.57	488.64	520.06	555.31	597.45
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-4.14	28.30	182.96	299.34	390.42	432.16	474.22	505.64	540.90	583.04
Strategy II Years 1-10: Low-level yields											
Gross income		415.43	545.62	694.45	752.43	807.08	844.80	880.32	918.97	956.93	995.68
less total costs[b]		477.03	590.85	711.55	733.14	757.57	775.96	791.59	809.43	826.81	844.61
Net returns		-61.60	-45.25	-17.10	19.29	49.51	68.84	88.73	109.54	130.12	151.07
less net financial costs		15.81	164.65	307.06	429.23	521.03	586.95	635.75	667.77	679.79	670.64
Net income before taxes		-77.41	-209.88	-324.16	-409.94	-471.52	-518.11	-547.02	-558.23	-549.67	-519.57
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-91.83	-224.30	-338.58	-424.36	-485.94	-531.53	-561.44	-572.65	-564.09	-533.99

[a] U.S. dollars. [b] Excluding financial charges. [c] Small errors due to rounding.

TABLE B.11 Chilalo: Summary of budget model accounts (t=0,...,10)

Item	Annual account summary at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Gross income	330.35	536.39	779.30	992.24	1,131.97	1,270.50	1,343.59	1,417.65	1,476.79	1,560.18	1,634.41
less total costs[b]	293.14	466.49	614.45	733.18	801.19	873.96	913.89	954.35	986.95	1,032.15	1,072.68
Net returns	37.21	69.90	164.85	259.06	330.78	396.54	429.70	463.30	489.84	528.03	561.73
less net financial costs	-	43.21	91.89	44.71	44.78	44.97	45.07	45.18	45.27	45.39	45.50
Net income before taxes	37.21	26.69	72.96	214.35	286.00	351.57	384.63	418.12	444.57	482.64	516.23
less taxes	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes	22.79	12.27	58.54	199.93	271.58	337.15	370.21	403.70	430.15	468.22	501.81
		Strategy I Years 1-10: Low-level yields									
Gross income		400.78	526.59	620.77	670.52	717.52	751.15	783.73	818.99	853.03	888.48
less total costs[b]		394.04	479.53	534.99	555.13	579.15	597.49	615.36	634.60	653.10	672.39
Net returns		6.74	47.05[c]	85.77	115.39	138.36	153.65	168.37	184.39	199.94	216.09
less net financial costs		43.04	158.97	240.27	285.79	302.90	296.66	273.68	233.40	173.21	92.22
Net income before taxes		-36.30	-111.92	-154.50	-170.40	-164.54	-143.01	-105.31	-49.01	26.73	123.87
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-50.72	-126.34	-168.92	-184.82	-178.96	-147.43	-119.73	-63.43	12.31	109.45
		Strategy II Years 1-10: High-level yields									
Gross income		575.87	833.19	1,146.60	1,311.47	1,474.16	1,553.50	1,633.30	1,694.68	1,786.94	1,866.84
less total costs[b]		549.71	719.55	912.30	980.45	1,052.02	1,089.57	1,127.25	1,157.16	1,214.12	1,251.84
Net returns		26.16	113.64	234.30	331.02	422.14	463.93	506.05	537.52	572.82	615.00
less net financial costs		15.88	70.92	36.93	17.26	17.31	17.36	17.41	17.46	17.51	17.55
Net income before taxes		10.28	42.72	197.37	313.76	404.83	446.57	488.64	520.06	555.31	597.45
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-4.14	28.30	182.96	299.34	390.42	432.16	474.22	505.64	540.90	583.04
		Strategy II Years 1-10: Low-level yields									
Gross income		415.43	545.62	694.45	752.43	807.08	844.80	880.32	918.97	956.93	995.68
less total costs[b]		477.03	590.85	711.55	733.14	757.57	775.96	791.59	809.43	826.81	844.61
Net returns		-61.60	-45.25	-17.10	19.29	49.51	68.84	88.73	109.54	130.12	151.07
less net financial costs		15.81	164.65	307.06	429.23	521.03	586.95	635.75	667.77	679.79	670.64
Net income before taxes		-77.41	-209.88	-324.16	-409.94	-471.52	-518.11	-547.02	-558.23	-549.67	-519.57
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-91.83	-224.30	-338.58	-424.36	-485.94	-531.53	-561.44	-572.65	-564.09	-533.99

[a] U.S. dollars. [b] Excluding financial charges. [c] Small errors due to rounding.

Additional Requirements

The budget model for the Chilalo case study represents two strategies by which improvements in mechanized agricultural technology may be introduced in the economy of small farmers. It is intended that there should be well-qualified supervisory personnel in the area, adequate storage facilities for cash crop production, and in strategy II adequate equipment available for cultivation and harvesting operations. The costs of these additional requirements are shown in Table B.12. These personnel and equipment are considered to be adequate for 150-200[1] farmers in strategy I and 50 farmers in strategy II forming an operational unit or cooperative. This unit covers an area of about 1,200-1,600 hectares of cultivated land in the case of strategy I and about 400 hectares in strategy II.

Supervision

Two technically competent individuals are to be appointed to the operational unit. Their duties cover demonstrations and guidance in the implementation of improved techniques, distribution of information and improved inputs to farmers, the recording and administration of loan transactions, the supervision of the Hire Service and, in cooperation with the Grain Corporation of Ethiopia, the supervision of storing and marketing cash crops. Some differentiation of duties is envisaged, thus the two appointees are given different titles: Extension Agent and Research Officer.

Equipment

In strategy I, in addition to supervisory, demonstration and recording duties, the operational unit is to be equipped for grain storage. In strategy II, in addition to storage facilities, a complete range of tillage and harvesting equipment is maintained on inventory for hire by farmers in the area (Table B.12).

Additional labor will be necessary in strategy I to store grain during the harvest period and to remove grain from storage for marketing. In strategy II additional personnel will be necessary to maintain the Hire Service: two tractor operators for eight months of the year and two additional driver-laborers to assist in grain transportation

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[1]An arbitrary figure of 175 was used in computations.

TABLE B.12 Chilalo: Estimated annual costs for additional personnel, equipment, and supporting costs for strategy I (150-200 farmers) and strategy II (50 farmers) during budget period (t=0,...,10)

Item	1	2	3	4	5	6	7	8	9	10
	Annual additional costs at indicated year									
	dollars*									
Strategy I (150-200 farmers)										
Personnel										
Salaries[a]	7,200	7,440	7,680	7,920	8,160	8,160	8,400	8,400	8,640	8,640
Per diem	800	800	800	800	800	800	800	800	800	800
Wages[b]	87	87	87	87	87	87	87	87	87	87
Subsistence[c]	8	8	8	8	8	8	8	8	8	8
Total	8,095	8,335	8,575	8,815	9,055	9,055	9,295	9,295	9,535	9,535
Vehicle[d]										
Cost (7% p.a.; 3 yr.)[e]	(1)[f] 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387
Maintenance	400	400	400	400	400	400	400	400	400	400
Fuel	800	800	800	800	800	800	800	800	800	800
Total	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Equipment										
Bins[i] (7% p.a.; 7 yr.)[e]	(6)[g] 445	(10) 742	(14) 1,039	(16) 1,188	(16) 1,188	(18) 1,337	(20) 1,486	(20) 1,041	(22) 893	(22) 596
Augur[h] (7% p.a.; 5 yr.)[e]	(1)[g] 32	(1) 32	(1) 32	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64
Total	477	774	1,071	1,252	1,252	1,401	1,550	1,105	957	660
Repair allowance	13	13	13	26	26	26	26	26	26	26
Total costs	12,372	12,909	13,446	13,880	14,120	14,269	14,658	14,213	14,305	14,008
Strategy II (50 farmers)										
Personnel										
Salaries & per diem	8,000	8,240	8,480	8,720	8,960	8,960	9,200	9,200	9,440	9,440
Wages[c]	989	989	989	989	989	989	989	989	989	989
Subsistence[c]	49	49	49	49	49	49	49	49	49	49
Total	9,038	9,278	9,518	9,758	9,998	9,998	10,298	10,298	10,478	10,478
Vehicle	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Equipment										
Tractors[j] (7% p.a.; 5 yr.)[e]	(2)[g] 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951
Disc plow[k] (7% p.a.; 7 yr.)[e]	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) -	(2) -	(2) -
Disc harrow[l] (7% p.a.; 7 yr.)[e]	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) -	(2) -	(2) -
Planter[m] (7% p.a.; 7 yr.)[e]	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) -	(2) -	(2) -
Grain drill[n] (7% p.a.; 7 yr.)[e]	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) -	(2) -	(2) -
Tool bar[o] (7% p.a.; 7 yr.)[e]	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) -	(2) -	(2) -
Cultivator[p] (7% p.a.; 7 yr.)[e]	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) -	(2) -	(2) -
Combine[q] (7% p.a.; 5 yr.)[e]	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244
Corn sheller[r] (7% p.a.; 5 yr.)[e]	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) -	(1) -	(1) -
Trailer[s] (7% p.a.; 5 yr.)[e]	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) -	(2) -	(2) -
Bins[t] (7% p.a.; 5 yr.)[e]	(6) 442	(10) 742	(14) 1,039	(16) 1,188	(18) 1,337	(20) 1,486	(22) 1,635	(22) 1,190	(24) 1,042	(24) 745
Augur[u] (7% p.a.; 5 yr.)[e]	(1) 32	(1) 32	(1) 32	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64
Total	6,849	7,149	7,446	7,627	7,776	7,925	8,074	5,449	5,301	5,004

Operating costs[v]	2,909	2,090	2,909	2,922	2,922	2,922	2,922	2,922	2,922	2,922
Total cost	22,583	23,123	23,660	24,094	24,483	24,632	25,081	22,456	22,488	22,191
Total costs less returns from hire-service										
High-level yields	13,511	12,079	10,641	11,084	11,411	11,539	11,966	9,318	8,612	8,291
Low-level yields	13,511	12,079	10,641	11,084	11,411	11,539	11,966	9,318	9,333	9,017

*U.S. dollars

[a]Extension Agent and Research Officer paid equally.

[b]Two laborers ($0.60 per day) employed for three months.

[c]Laborers' and drivers' food allowance: $0.10 per day.

[d]Land Rover @ $3,640 each acquisition price.

[e]Amortization charge; rate in parenthesis to each item. Period of amortization adjusted to effect loan repayment within depreciation period. Annual depreciation rates: vehicles, 33%; tractors, combines, augurs, 20%; cultivating equipment, 10%; bins, 5%.

[f]Bins: capacity, 500 quintals; @ $400 each.

[g]Number of equipment units contained in parenthesis.

[h]Augur: 6" dia., 3 h.p. engine; @ $130 each.

[i]One driver-mechanic and one driver employed for eight months plus two additional drivers during harvest time at $48.00 per month each; two laborers for one month at $0.60 per day each.

[j]Tractors: 45 h.p. @ $4,000 each.

[k]Plow: 3 furrow disc @ $800 each.

[l]Disc harrow: 3 disc (7 m. wide) @ $800 each.

[m]Planter: 4 row @ $1,200 each.

[n]Drill: 3.7 m. wide @ $1,580 each.

[o]Tool bar: $200 each.

[p]Cultivator: 2 row @ $700 each.

[q]Combine: 3.7 m. wide @ $9,200 each.

[r]Sheller: power-take-off @ $400 each.

[s]Trailer: 9 metric ton @ $400.

[t]Bins as in strategy I.

[u]Augur as in strategy I.

[v]Fuel/allowance $300 per tractor and $300 for combine; repair and maintenance 6.5% on capital investment-costs.

Source: U.S. Agency for International Development, Shashamanne Farm Development Project . . ., pp. 32-33, A.i-vi.

and storage during the two months of combining; two laborers are to be hired for a total of one month each to assist in dispatching grain to market. One of the tractor drivers should have sufficient mechanical skills to perform field maintenance and repair work.

Infrastructure

Asela and the surrounding area of Chilalo is already served by a major road. Farm roads are extremely rough but passable for agricultural equipment. Much needs to be done to improve the feeder road system. General improvements in road facilities throughout the Empire are anticipated in the Ethiopian Third Five-Year Development Plan.[1]

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[1]Imperial Ethiopian Government, Third Five-Year Plan . . ., p. 46.

APPENDIX C

SETIT-HUMERA CASE STUDY

APPENDIX C

SETIT-HUMERA CASE STUDY

Introduction

The third case lies in the remote Province of Begemdir and Simen close to the Sudanese border about 750 kilometers northwest of Addis Abeba. The Setit-Humera area, lying between the Setit and Angareb Rivers, is roughly divisible into two parts: 350,000 hectares bounded by the Tekeze River, the northern branch of the Angareb River, the Sudanese border and longitude 37° East; and 150,000 hectares lying south of the northern branch of the Angareb River, bounded by the Sudanese border and longitude 37° East. The first area, at an elevation of 600 meters, consists of 175,000 hectares farmed entirely by tractor and another 52,000 hectares of useful land not yet being farmed; the second area, at an elevation between 600 and 1,000 meters, consists of 30,000 hectares of useful farmland of which less than 1 per cent is farmed. Farming in second area is entirely by oxen. Humera (location: 14°20' North, 37°60 East) on the Tekeze River is the principal town of the area.

Recently, the area has been developed primarily by private entrepreneurs using modern engine-powered equipment although a large number of oxen farmers with small farms of six to eight hectares have settled in the fringes of the area during the past 50 years. Concessions of land, hitherto unsettled and uncultivated, have been relatively easy to obtain through the local vice-governor's office. The area of concessions vary from 400 to 1,000 hectares (the first one was 7,000 hectares, on a 70-year lease); no titles, other than leases, have been granted.

The soils are described as vertisols (self-mulching, black cotton soil) containing about 50 per cent clay.[1] African soils of this classification are among the

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[1]Kline, _et al._, _op_. _cit_., Pt. II, p. 135.

best soils for growing cotton, maize, wheat, sorghum, oilseeds, rice, tobacco, fodder crops and pasture grasses.[1]

No irrigation is practiced despite its proximity to the Tekeze River. The surrounding farmland is considerably higher than the river, irrigation pumping would be a costly operation. Local agriculture depends entirely on annual rainfall which is a major limiting factor. Rainfall data is recorded in Table C.1.

The Setit-Humera area is of considerable interest to the Imperial Ethiopian Government and development agencies because of its high economic potential. A large number of migrant laborers are employed annually by the farmers although there is also extensive employment of engine power in the cultivation operations. Economic expansion in the area has been rapid and unplanned over the past ten years. Supportive infrastructure has not been adequately developed. Facilities for the provision of drinking water, housing, transportation, communication and medical services are all poor. There are shortages of storage facilities, credit accommodation, labor and general agricultural services.[2] At present the inadequately developed infrastructure is a serious threat to economic expansion of the Setit-Humera area.

This case study has been prepared from observations made in the area during the 1968-69 season (t=0) and data published by the Institute of Agricultural Research.[3] Supplementary data for the many assumptions were obtained largely from materials published by Stanford Research Institute.[4]

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[1] Report of the Survey Mission on the Agricultural Development of Setit-Humera, 31 October-3 November, 1967 (Addis Abeba: Institute of Agricultural Research, December, 1967), pp. 10-11.

[2] Ibid., p. 6.

[3] Ibid.

[4] Carl F. Miller, et al., Systems Analysis Methods . . . .

TABLE C.1 Setit-Humera: Climatic data and distribution of crop operations by calendar months, budget model initiating year (t=0)

Item	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Season	Dry							Wet				
Mean rainfall[a] (mm.)	-	-	-	-	5.0	24.1	64.7	189.7	217.3	100.4	11.7	2.5
Mean temperature[a] (°C)	26.7	25.5	26.4	29.0	32.1	32.4	31.0	28.1	26.7	28.1	29.8	28.7
Crop operations in current practice[b]												
Sesame						disc, plant			weed			harvest
Cotton		pick					disc, plant				weed	
Grain sorghum			harvest					disc, plant				weed

[a]Carl F. Miller, et al., Systems Analysis Methods . . ., p. 66.

[b]Report of the Survey Mission . . ., pp. 18-21.

Present Agricultural Economy

The People and Their Habitat

Currently, the area is one of rapid, unplanned expansion. Experienced and inexperienced farmers have been able to obtain land with relative ease and have established homesteads throughout the area.

Some 60,000 migrant workers come into the area annually for employment during the planting and weeding season beginning in May and for the harvest season beginning in October. Farmers have built simple forms of accommodation on their farms for their labor force.

Humera, with a population of 20,000 in 1967, is the local market and trading center as well as the center for administration, security and law enforcement. The town is the collection and storage point for agricultural produce to be transported to Asmera, the principal market, some 430 kilometers east. Since there is no local marketing organization, most farmers are obliged to sell their crops to local merchants to whom they are heavily indebted by harvest time. Larger and more progressive farmers sell in Asmera. Transportation involves double handling because no bridge exists over the Tekeze River. Tractors are only able to haul produce across the river during the period January through May, and the road connection to the main all-weather route from Asmera to Tessenei is only passable for trucks during the dry season.[1] Farm roads and main roads within the area are extremely poor.[2]

Until settlement began some ten years ago, there was no indigenous population other than nomadic herdsmen and camel caravan drovers. Thus, the area is virgin agricultural country in which the number of scattered farmsteads is gradually increasing.

The average size of farm is 800 hectares. Under present conditions one tractor is sufficient to farm about 40 hectares; one tractor is required for hauling water and for general transportation.[3] Thus, many farms of this average size are likely to use three tractors. Three tractors appear to be more useful than two tractors and a Land Rover since one additional tractor is available for the early tillage operations and is used for general

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[1] _Ibid._, p. 13-14. [2] _Ibid._ [3] _Ibid._, p. 25.

haulage and transport for the rest of the year; the farmer can make long distance journeys by grain truck or by the bus service.[1]

Agricultural Practices

In the initiating year (t=0), the distribution of crops was observed to be: grain sorghum, 45 per cent; sesame, 30 per cent; cotton, 25 per cent. This year of observation followed a substantial decline in the market price of grain sorghum in Asmera and, consequently shows a marked decline from the proportions of crops observed by the Mission from the Institute of Agricultural Research which reported crop dispositions for the 1967-68 season as grain sorghum, 55 per cent; sesame, 16 per cent; cotton, 29 per cent. The cropping pattern appears to be quite sensitive to changes in market prices.

Usually each farmer grows all three crops each year. No particular pattern of rotation is followed; when an area becomes weedy grain sorghum, which tends to compete against weeds more successfully, is planted in the following season. Fallow cultivation is not practiced. Crop areas are determined on the basis of market considerations with the exception of grain sorghum which is both the important subsistence crop of the area and an important cash crop; therefore the area of sorghum grown is determined by both market considerations and local consumption requirements.

Despite the current dependence of farmers on hand labor a wide variety of tractor equipment is also employed in the area.[2] The annual capital inventories are shown in Table C.2(a). The principal cultivation implement is the wide-level disc harrow (18-24 discs).

Data presented throughout this case study are for two strategies, the basic differences between these two strategies are depicted in Table C.2(a). In strategy I less tractor equipment is employed than in strategy II: all planting, weeding, thinning, spraying, harvesting and clearing operations are to be performed by hand in strategy I; tractor equipment is to be employed for some of the crops in planting, cultivating, and clearing operations, and grain sorghum is to be harvested by combine in strategy II.

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[1] *Ibid.*, p. 14.

[2] *Ibid.*, p. 24.

TABLE C.2 Setit-Humera: Basic assumptions
a. Total annual cost of capital inventory in operation[a] for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Item	0	1	2	3	4	5	6	7	8	9	10
	Annual capital cost at indicated year — dollars[b]										
		Strategy I									
Tractor equipment[c]	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,200
Sprayers[d]		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Hand tools[e]	378	567	587	590	596	599	603	606	610	614	614
Grain bins[f]		1,800	1,800	1,800	1,800	1,800	1,800	2,000	2,000	2,000	2,000
Total	17,598	22,587	22,607	22,610	22,616	22,619	22,623	22,826	22,830	22,834	22,834
		Strategy II									
Tractor equipment[g]		20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720
Combine		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Sprayers		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Hand tools		416	437	455	461	464	468	470	473	473	473
Grain bins		1,400	1,400	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Total		37,536	37,557	37,775	37,781	37,784	37,788	37,790	37,793	37,793	37,793

[a] Equipment in current operation, and not fully depreciated, valued at acquisition price.

[b] All dollar values for these analyses are U.S. dollars.

[c] Three 65-75 h.p. wheel tractors @ $4,200 each; three wide-level disc harrows (24 discs) @ $940 each; two 3-ton trailers @ $900. Tractor equipment depreciated at 10 per cent of acquisition per annum.

[d] Thirty back-pack sprayers @ $100 each. Depreciated at 25 per cent of acquisition cost per annum.

[e] Hand-hoes for weeding and cultivating over a period of 156 working days and sickles for hand harvesting grain sorghum and sesame over 212 working days. Tools valued at $1.80 each and depreciated at 10 per cent of acquisition cost per annum.

[f] Capacity 200 quintals each for storing grain sorghum required for local food supply. Valued at $250 each and depreciated at 10 per cent of acquisition price per annum.

[g] Equipment used in strategy I plus one seed planter @ $1,160; one cultivator @ $1,300; one rotary slasher @ $1,040.

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., p. 98.

TABLE C.2 Continued

b. Price and annual yield assumptions, budget model (t=0,...,10)

Crop	Variety	Production level	Price	Annual yield at indicated year										
				0	1	2	3	4	5	6	7	8	9	10
			$/q.[a]	quintals per hectare										
Sesame	Morado	H[b]	20.15	6.0[d]	6.3[e]	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0
		L[c]			6.2	6.3	6.5	6.7	6.8	7.0	7.2	7.4	7.5	7.7
Cotton	Acala 1517 or 4.42	H	25.00	3.0[d]	3.4[e]	3.9	4.3	4.8	5.2	5.7	6.1	6.6	7.0	7.5
		L			3.2	3.4	3.4	3.9	4.1	4.3	4.6	4.8	5.0	5.3
Grain sorghum		H	4.84	15.0[d]	15.5[e]	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
		L			15.2	15.5	15.8	16.0	16.2	16.5	16.8	17.0	17.2	17.5
Haricot beans	Negro Mecentral	H	9.60	-	8.0[f]	9.3	10.6	11.9	13.3	14.6	15.9	17.3	18.6	20.0
		L			8.0	8.6	9.3	10.0	10.6	11.3	12.0	12.6	13.3	14.0

[a]U.S. dollars. [b]High-level yields. [c]Low-level yields.

[d]Based on field observations: Report of the Survey Mission . . ., p. 31.

[e]Improved yields based on estimated attainable yields under improved cultivation practices: Carl F. Miller, et al., Systems Analysis Methods . . ., p. 289.

[f]Yield possibility for haricot (dry) beans calculated from combined production function: $Y = Y_m \prod_{i=1}^{7} \Phi_i$

where: $\Phi_2 \cdot \Phi_3 = (2-T/T_m)(2-R/R_m)(T/T_m)(R/R_m)$, $T=28.67$, $T_m=20$, $R=.051279$, $R_m=.120$;

$\Phi_4 \cdot \Phi_5 \cdot \Phi_6 = .792$;

$\Phi_7 = .8$;

and $Y_m = 66.6$.

Ibid., pp. 119-203.

TABLE C.2 Continued
c. Cultivation practices for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Operation	Number of operations in initiating year for indicated crop			Number of operations in each year of strategy I for indicated crop				Number of operations in each year of strategy II for indicated crop			
	Sesame	Cotton	Sorghum	Sesame	Cotton	Sorghum	Beans	Sesame	Cotton	Sorghum	Beans
	number of operations										
Disc plow											
--mechanical	2	2	2	2	2	2	2	2	2	2	2
Plant--hand	1	1	1	1	1	1	1	1	-	-	1
--mechanical	-	-	-	-	-	-	-	-	1	1	-
Disc plow											
--mechanical	1	1	1	1	1	1	1	-	-	-	-
Cultivate											
--hand	-	1	1	1	1	1	1	1[a]	-	-	1[a]
--mechanical	-	-	-	-	-	-	-	-	2	2	-
Weed & thin											
--hand	2	2	1	2	2	1	2	1[a]	1[a]	-	1[a]
Spray--hand	-	-	-	1	-	1	1	1[a]	-	1[a]	1[a]
--aerial	-	-	-	-	3	-	-	-	3	-	-
Harvest											
--hand	1	2-3	1	1	2-3	1	1	1	2-3	-	1
--mechanical	-	-	-	-	-	-	-	-	-	1	-
Thresh &											
winnow--hand	1	-	1	1	-	1	1	1	-	-	1
Clear--hand	1	1	1	1	1	1	-	1	-	1	-
--mechanical	-	-	-	-	-	-	-	-	1	-	-

[a]These hand operations are maintained in order to retain hand labor force in occupation until harvesting begins.

Source: Carl F. Miller et al., Systems Analysis Methods . . ., pp. 242-43.

TABLE C.2 Continued
d. Estimated costs for manual and machine operations, budget model (t=0,...,10)

Operation	Manual and machine crop[a] operation according to indicated strategy				Manual operation		Machine operations	
	Strategy I		Strategy II					
	Manual	Machine	Manual	Machine	Rate	Cost	Rate	Cost
					man-days/ ha.	$/day[b]	machine-days/ha.	$/day[b]
Discing	-	all	-	all	-	-	.1667	24.83[c]
Planting	all	-	S,B	C,Sm	5.0	.80	.10	28.08
Cultivating	-	-	S,B	C,Sm	20.0	.60	.125	22.72
Weeding &								
thinning	all	-	S,C,B	-	13.4	.60	-	-
Spraying	all	-	S,Sm,B	-	1.0	.60	-	-
Clearing	S,C,Sm	-	S,Sm	C	20.0	.60	.125	26.20
Harvesting	S	-	S	-	$28.00/ha	.60	-	-
	C	-	C	-	$ 2.00/q.	.60	(.0705[d]	-
	Sm	-	-	Sm	$ .60/q.	.60	(.0941	66.76
	B	-	B	-	$ 4.00/ha.	.60		-
Threshing &								
winnowing	S	-	S	-	$ .80/q.	.60	-	-
	Sm	-	-	-	$ .40/q.	.60	-	-
	B	-	B	-	$ .60/q.	.60	-	-

[a]Sesame = S, Cotton = C, Grain Sorghum = Sm, Haricot beans = B.

[b]U.S. dollars.

[c]Machine costs calculated from data which included capital recovery charges (published by Stanford Research Institute). This budget model includes depreciation as an operating charge, therefore capital recovery charge included in original data has been deducted.

[d]Combine operating rate reduced for heavy crop yields: 14.175 ha./day (.0705 days/ha.) if $Y_{X_i} < 31.36$ q/ha., 10.63 ha./day (.0941 days/ha.) if $Y_{X_i} \geq 31.36$ q/ha.

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., pp. 98-99.

In terms of equipment, there is no change in strategy I from already established inventories of equipment. The change from current practice lies in cultivation practices to be discussed later. In strategy II there are changes both in cultivation practices and in equipment to handle the productive processes.

Crop yields for the initiating year are recorded in Table C.2(b). The differences in cultivation practices between strategy I (t=1,...,10), strategy II (t=1,...,10) and the current practice observations for the initiating year (t=0) are set out in Table C.2(c).

Production and Value of Crops

Until 1967 grain sorghum had been the major cash crop of Setit-Humera area when prices for grain sorghum fell dramatically to $4.6[1] in April, 1968. This fall led to a readjustment in the allocation of land in the 1968-69 season. Farmers anticipated little change in relative prices for the forthcoming season and anticipated a general movement in the area out of grain sorghum production into sesame and cotton production. Thus, the initiating year of the budget model has been established on the basis of average seasonal crop prices for the 1967-68 season.[2] These prices are recorded in Table C.2(b).

The quantity of grain sorghum consumed by the laboring population has been calculated on the basis of a basic requirement of .018 quintals per man-day of work[3] constituting the non-cash portion of the wage payment. The quantity of grain sorghum required by the labor force constitutes a minimum constraint to the farmer in planning the disposition of crops from one season to the next.

Estimated costs of manual and machine operations are recorded in Table C.2(d). During most of the season manual labor is currently employed at $0.60 per day for an eight-hour day; for hand planting (broadcasting) which tends to be more intensive work and for a longer working day (8-10 hours), $0.80 per day is paid currently. Tractor

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[1]All dollar values are U.S. dollars.

[2]Ibid., p. 39.

[3]Assuming a six-day week this rule of thumb is approximately the same as that used for Agnale Village.

drivers receive the equivalent of $2.00 per day.[1] During harvesting different arrangements are currently established for different crops: sesame is harvested by contract on the basis of area to a harvest-gang leader; cotton and grain sorghum are harvested by payment on the basis of weight to individual harvesters.

Technological Improvements

Mechanized agricultural technology is established from the beginning in this case study. Thus, technological improvements are directed toward improvements in cultivation techniques, the development of new varieties, and control of insect pests. Improvements in infrastructure, much needed for the economic development of this area, are to be discussed below.

Hand Tools

No change has been anticipated in the type or design of hand tools employed. Two tools are widely used, the hoe for weeding and cultivating and the sickle for harvesting. These tools are similar to those described for Chilalo. The number of hand tools required were estimated for the capital inventories recorded in Table C.2(a) on the basis of man-days of manual labor required during the cropping season.

Grain Storage

Farmers store on the farm only that portion of the grain sorghum crop required as food for hired laborers. All other crops are hauled by tractor to Humera and across the river to be loaded onto trucks for transportation to Asmera. Grain sold to merchants in Humera is kept in a wide variety of storage places until merchants are able to find tractor haulage across the river to the truck loading point.

Wastage on the farm has been assumed to be in the region of 15 per cent in the initiating year. With the introduction of improved storage bins wastage has been reduced to 3 per cent in the operational years (t=1,...,10) of the budget model.

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[1]Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 99.

Crop Yields and Areas

Assumed levels of crop yields for the budget model are shown in Table C.2(b). Assumed yields for sesame, cotton, and grain sorghum are an approximation of those suggested as obtainable[1] by using the improved cultivation practices shown in Table C.2(d). These approximations were determined by taking into account other observations on yield possibilities in the area.[2] Assumed yields for haricot beans were calculated by using the combined production function already discussed in the Agnale case study. The determined maximum yield is close to that suggested as being attainable[3] under improved cultivation practices.

Maximum attainable yield has been assumed for each crop in the final year (high-level) of the budget model; annual yield increments are equal. Low-level yields were arbitrarily assumed to be approximately three-quarters of the maximum attainable yields.

In this case study the farmer takes crop profitability into account in deciding the area of each crop to be grown each season. The decision involves crop yields, anticipated market prices and production costs. As in the Chilalo case study, a simple decision-making algorithm was built into the budget model in order to determine crop areas year by year. The algorithm was based on farmers' responses in interview that the decision of how many hectares of a crop to grow was made on the basis of its profitability in the preceding year. Profitability appeared to be determined in the farmer's mind as an operating margin of gross income less direct costs for each crop.

In the model the procedure is: first, for the year preceding the current season, to determine the operating margin (per unit area) on each crop and the average operating margin (per unit area) for all crops; second, for the current season, to increase the area of those crops which are more profitable than the average in proportion to their profitability: the total increase in the area of more

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[1] Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 289.

[2] *Report of the Survey Mission . . .*, pp. 21-23.

[3] 26.6 quintals per hectare: Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 289.

TABLE B.6 Chilalo: Summary of annual gross incomes, budget model (t=0,...,10)

Income	Crop	Annual gross incomes at indicated year										
		0	1	2	3	4	5	6	7	8	9	10
		dollars[a]										
		Strategy I Years 1-10: High-level yields										
Non-cash	Food & cash	117.42	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86
Cash	Cash	200.47	357.08	597.34	808.94	948.65	1,087.14	1,160.21	1,234.24	1,293.36	1,376.73	1,450.94
Other	-	12.45	12.44	15.09	16.44	16.46	16.49	16.52	16.54	16.57	16.59	16.61
Total		330.35	536.39	779.30	992.24	1,131.97	1,270.50	1,343.59	1,417.65	1,476.79	1,560.18	1,634.41
		Strategy I Years 1-10: Low-level yields										
Non-cash	Food & cash		166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86	166.86
Cash	Cash		221.47	344.63	437.47	487.19	534.16	567.77	600.33	635.56	669.58	705.01
Other	-		12.44	15.09	16.44	16.46	16.49	16.52	16.54	16.57	16.59	16.61
Total			400.78	526.59	620.77	670.52	717.52	751.15	783.73	818.99	853.03	888.48
		Strategy II Years 1-10: High-level yields										
Non-cash	Food & cash		101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61
Cash	Cash		461.56	716.23	1,027.00	1,191.85	1,354.52	1,433.85	1,513.62	1,574.99	1,667.23	1,747.12
Other	-		12.71	15.35	17.99	18.01	18.03	18.05	18.07	18.08	18.10	18.11
Total			575.87	833.19	1,148.60	1,311.47	1,474.16	1,553.50	1,633.30	1,694.68	1,786.94	1,866.84
		Strategy II Years 1-10: Low-level yields										
Non-cash	Food & cash		101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61	101.61
Cash	Cash		301.11	428.66	574.85	832.81	687.44	725.14	760.65	799.27	837.22	875.96
Other	-		12.71	15.35	17.99	18.01	18.03	18.05	18.07	18.08	18.10	18.11
Total			415.43	545.62	694.45	752.43	807.08	844.80	880.32	918.97	956.93	995.68

[a]U.S. dollars. [b]Small errors due to rounding.

TABLE B.7 Chilalo: Annual labor use in field operations, budget model (t=0,...,10)

Operation	Annual field labor requirements at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	man-hours										
	Strategy I Years 1-10: High-level yields										
Plowing	358	329	337	303	242	242	242	242	242	242	242
Seeding	255	148	176	191	191	164	164	164	164	164	164
Weeding	482	1,047	1,230	1,279	1,211	1,216	1,221	1,226	1,231	1,235	1,240
Harvesting	614	934	1,338	1,686	1,910	2,132	2,261	2,392	2,500	2,644	2,775
Threshing/winnowing	327	471	677	858	977	1,095	1,158	1,222	1,273	1,344	1,408
Total	2,036	2,929	3,758	4,317	4,531	4,849	5,046	5,246	5,410	5,629	5,829
	Strategy I Years 1-10: Low-level yields										
Plowing		329	337	303	242	242	242	242	242	242	242
Seeding		148	176	191	191	164	164	164	164	164	164
Weeding		1,046	1,230	1,279	1,211	1,216	1,221	1,226	1,231	1,235	1,239
Harvesting		711	924	1,081	1,161	1,237	1,293	1,349	1,408	1,465	1,524
Threshing/winnowing		358	465	545	587	627	656	684	714	743	773
Total		2,592	3,132	3,399	3,392	3,486	3,576	3,665	3,759	3,849	3,942
	Strategy II Years 1-10: High-level yields										
Plowing		-	-	-	-	-	-	-	-	-	-
Seeding		9	9	8	8	7	7	7	7	7	6
Weeding		1,138	1,313	1,462	1,380	1,383	1,385	1,388	1,391	1,393	1,395
Harvesting		495	633	787	848	911	975	1,039	1,098	1,160	1,224
Threshing/winnowing		205	253	308	330	352	375	398	419	441	463
Total		1,847	2,208	2,565	2,566	2,653	2,742	2,831	2,915	3,001	3,088
	Strategy II Years 1-10: Low-level yields										
Plowing		-	-	-	-	-	-	-	-	-	-
Seeding		9	9	8	8	7	7	7	7	7	6
Weeding		1,137	1,313	1,462	1,380	1,383	1,385	1,388	1,391	1,393	1,395
Harvesting		394	473	560	581	601	621	642	662	682	703
Threshing/winnowing		169	197	227	234	241	248	255	262	269	276
Total		1,709	1,992	2,257	2,203	2,232	2,261	2,292	2,322	2,351	2,380

TABLE B.8 Chilalo: Inputs of seeds, budget model (t=0,...,10)

Crop	Seed price at indicated year		Seed rate at indicated year	
	0	1-10	0	1-10
	---------$/q.---------		--------q/ha.----------	
Wheat	8.20	10.00	1.15	1.00
Barley	5.60	8.00	1.16	1.00
Maize	4.00	6.00	.60	.30
Teff	9.80	15.20	.50	.22
Flax	15.00	18.00	.74	.25
Peas	5.20	6.00	1.31	.90
Beans	5.00	6.00	.90	.90

TABLE B.9 Chilalo: Summary of annual total costs for inputs (excluding financial charges), budget model (t=0,...,10)

Year	Labor Non-cash	Labor Cash	Seed Non-cash	Seed Cash	Sacks Cash	Rent Cash	Depreciation Non-cash	Depreciation Cash	Total inputs Non-cash	Total inputs Cash	Total inputs Total
	dollars[a]										
0	59.00	42.81	37.36	-	4.82	126.20	12.00	10.95	108.36	184.78	293.14
Strategy I Years 1-10: High-level yields											
1	110.00	36.43	-	37.33	7.19	208.01	-	67.54	110.00	356.49[b]	466.49[b]
2	110.00	77.88	-	45.28	10.35	301.39	-	67.54	110.00	504.45	614.45
3	110.00	105.83	-	49.32	13.10	387.19	-	67.54	110.00	623.18	733.18
4	110.00	116.53	-	49.39	14.88	442.86	-	67.54	110.00	691.19	801.19
5	110.00	132.46	-	49.48	16.65	497.84	-	67.54	110.00	763.96	873.96
6	110.00	142.31	-	49.55	17.65	526.85	-	67.54	110.00	803.89	913.89
7	110.00	152.29	-	49.63	18.66	556.24	-	67.54	110.00	844.35	954.35
8	110.00	160.52	-	49.70	19.48	579.71	-	67.54	110.00	876.95	986.95
9	110.00	171.44	-	49.76	20.60	612.81	-	67.54	110.00	922.15	1,032.15
10	110.00	181.43	-	49.83	21.62	642.27	-	67.54	110.00	962.68	1,072.68
Strategy I Years 1-10: Low-level yields											
1	110.00	19.58	-	37.33	5.42	154.17	-	67.54	110.00	284.04	394.04
2	110.00	45.59	-	45.28	7.06	203.06	-	67.54	110.00	369.53	479.53
3	110.00	59.94	-	49.32	8.29	239.92	-	67.54	110.00	424.99	534.99
.4	110.00	59.63	-	49.39	8.92	259.66	-	67.54	110.00	445.13	555.13
5	110.00	64.31	-	49.48	9.52	278.31	-	67.54	110.00	469.15	579.15
6	110.00	68.80	-	49.55	9.96	291.65	-	67.54	110.00	487.49	597.49
7	110.00	73.23	-	49.63	10.40	304.58	-	67.54	110.00	505.36	615.36
8	110.00	77.94	-	49.70	10.86	318.56	-	67.54	110.00	524.60	634.60
9	110.00	82.24	-	49.76	11.31	332.07	-	67.54	110.00	543.10	653.10
10	110.00	87.12	-	49.83	11.77	346.13	-	67.54	110.00	562.39	672.39

Year	Labor Non-cash	Labor Cash	Seed Non-cash	Seed Cash	Sacks Cash	Rent Cash	Depreciation Non-cash	Depreciation Cash	Hire charges Cash	Total inputs Non-cash	Total inputs Cash	Total inputs Total
	dollars[a]											
Strategy II Years 1-10: High-level yields												
1	55.00	37.34	-	38.12	7.63	223.58	-	6.60	207.13	55.00	497.71	549.71
2	55.00	55.38	-	46.04	10.96	324.68	-	6.60	220.87	55.00	664.55	719.55
3	55.00	73.27	-	53.98	15.01	448.06	-	6.60	260.38	55.00	857.30	912.30
4	55.00	73.31	-	54.03	17.10	513.50	-	6.60	260.91	55.00	925.45	980.45
5	55.00	77.65	-	54.09	19.17	578.08	-	6.60	261.43	55.00	997.02	1,052.02
6	55.00	82.14	-	54.14	20.25	609.58	-	6.60	261.86	55.00	1,034.57	1,089.57
7	55.00	86.57	-	54.20	21.34	641.25	-	6.60	262.30	55.00	107.25	1,127.25
8	55.00	90.75	-	54.25	22.21	665.61	-	6.60	262.75	55.00	1,102.16	1,157.16
9	55.00	95.02	-	54.29	23.44	702.23	-	6.60	277.53	55.00	1,159.12	1,214.12
10	55.00	99.42	-	54.34	24.54	733.95	-	6.60	277.99	55.00	1,196.84	1,251.84
Strategy II Years 1-10: Low-level yields												
1	55.00	30.47	-	38.12	5.52	159.88	-	6.60	181.44	55.00	422.03	477.03
2	55.00	44.60	-	46.04	7.22	210.52	-	6.60	220.87	55.00	535.85	590.85
3	55.00	57.88	-	53.98	9.16	268.55	-	6.60	260.38	55.00	656.55	711.55
4	55.00	55.15	-	54.03	9.89	291.56	-	6.60	260.91	55.00	678.14	733.14
5	55.00	56.61	-	54.09	10.59	313.25	-	6.60	261.43	55.00	702.57	757.57
6	55.00	58.06	-	54.14	11.08	328.22	-	6.60	261.86	55.00	719.96	775.96
7	55.00	59.63	-	54.20	11.55	342.32	-	6.60	262.30	55.00	736.59	791.59
8	55.00	61.12	-	54.25	12.06	357.65	-	6.60	262.75	55.00	754.43	809.43
9	55.00	62.54	-	54.29	12.56	372.72	-	6.60	263.10	55.00	771.81	826.81
10	55.00	64.02	-	54.34	13.06	388.10	-	6.60	263.49	55.00	789.61	844.61

[a] U.S. dollars. [b] Small errors due to rounding.

Financial Costs

Financial costs are less complicated in this case than in the case of Agnale. There is no long-term investment (such as tree crops) in which productive returns are delayed for a number of years after having made the initial investment.

An assumption has been made that a short-term crop loan can be arranged to finance operating costs until the proceeds from harvest are available to meet these expenses. This arrangement is to be made at an interest rate of 8 per cent per annum charged on a monthly basis. Repayment of the crop loan is made at the end of each February following harvest in December and January. Costs of plowing, planting, seeds, weeding, and harvesting are all covered by the crop loan.

Medium-term loan accommodation is to be arranged to cover costs of purchasing tools and equipment. Repayment of principal with interest has been amortized at 7 per cent per annum over a period of seven years with the exception of the costs for oxen. Loans for the purchase of oxen are to be repaid over six years since this period is the maximum estimate for their working life.

Additional bank accommodation has also been arranged to cover animal losses. A negative cash margin for any year has been accommodated on overdraft terms (short-term loans) at 7 per cent per annum carried forward into the following year as a financial charge.

Depreciation on tools and equipment is a legitimate operating cost and has been charged in the input accounts. However, since the purchase of equipment has been funded from loans, the accumulated depreciation account has been used as a cash fund toward the payment of outstanding charges on the loan account. Details of financial charges and net financial costs are set out in Table B.10.

Budget Summary

The accounts of the budget model are summarized in Table B.11. In this case the individual farmer is assessed a land tax which has been charged at a rate of $1.68 per hectare.[1] Net income is recorded in the table before and after taxation.

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[1]Leander, op. cit., pp. 76, 79.

TABLE B.10 Chilalo: Annual financial charges and net financial costs, budget model (t=0,...,10)

Item	Annual financial charges and costs at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Crop loan	-	4.11	5.08	5.61	5.68	5.87	5.97	6.08	6.17	6.29	6.40
Overdraft	-	-	47.71	-	-	-	-	-	-	-	-
Medium term loan	-	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64
Total	-	110.75	159.43	112.25	112.32	112.51	112.61	112.72	112.81	112.93	113.04
Less depreciation fund	-	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54
Net financial costs	-	43.21	91.89	44.71	44.78	44.97	45.07	45.18	45.27	45.39	45.50
		Strategy I Years 1-10: Low-level yields									
Crop loan		3.94	4.76	5.15	5.11	5.19	5.24	5.29	5.35	5.40	5.45
Overdraft		-	115.11	196.02	241.58	258.61	252.32	229.29	188.95	128.71	47.67
Medium term loan		106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64	106.64
Total		110.58	226.51	307.81	353.33	370.44	364.20	341.22	300.94	240.75	159.76
Less depreciation fund		67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54	67.54
Net financial costs		43.04	158.97	240.27	285.79	302.90	296.66	273.68	233.40	173.21	92.22
		Strategy II Years 1-10: High-level yields									
Crop loan		3.92	4.67	5.39	5.31	5.36	5.41	5.46	5.50	5.55	5.60
Overdraft		-	54.30	19.59	-	-	-	-	-	-	-
Medium term loan		18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56
Total		22.48	77.53	43.54	23.87	23.92	23.97	24.02	24.06	24.11	24.16
Less depreciation fund		6.60	6.60[b]	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
Net financial costs		15.88	70.92	36.93	17.26	17.31	17.36	17.41	17.46	17.51	17.55
		Strategy II Years 1-10: Low-level yields									
Crop loan		3.85	4.56	5.23	5.12	5.15	5.17	5.19	5.21	5.23	5.24
Overdraft		-	148.13	289.87	412.15	503.93	569.83	618.61	650.61	662.61	653.44
Medium term loan		18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56	18.56
Total		22.41	171.25	313.66	435.83	527.64	593.56	642.36	674.38	686.40	677.24
Less depreciation fund		6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60	6.60
Net financial costs		15.81	164.65	307.06	429.23	521.03	586.95	635.75	667.77	679.79	670.64

[a] U.S. dollars

[b] Small errors due to rounding.

TABLE B.11 Chilalo: Summary of budget model accounts (t=0,...,10)

Item	Annual account summary at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
	Strategy I Years 1-10: High-level yields										
Gross income	330.35	536.39	779.30	992.24	1,131.97	1,270.50	1,343.59	1,417.65	1,476.79	1,560.18	1,634.41
less total costs[b]	293.14	466.49	614.45	733.18	801.19	873.96	913.89	954.35	986.95	1,032.15	1,072.68
Net returns	37.21	69.90	164.85	259.06	330.78	396.54	429.70	463.30	489.84	528.03	561.73
less net financial costs	-	43.21	91.89	44.71	44.78	44.97	45.07	45.18	45.27	45.39	45.50
Net income before taxes	37.21	26.69	72.96	214.35	286.00	351.57	384.63	418.12	444.57	482.64	516.23
less taxes	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes	22.79	12.27	58.54	199.93	271.58	337.15	370.21	403.70	430.15	468.22	501.81
	Strategy I Years 1-10: Low-level yields										
Gross income		400.78	526.59	620.77	670.52	717.52	751.15	783.73	818.99	853.03	888.48
less total costs[b]		394.04	479.53	534.99	555.13	579.15	597.49	615.36	634.60	653.10	672.39
Net returns		6.74	47.05[c]	85.77	115.39	138.36	153.65	168.37	184.39	199.94	216.09
less net financial costs		43.04	158.97	240.27	285.79	302.90	296.66	273.68	233.40	173.21	92.22
Net income before taxes		-36.30	-111.92	-154.50	-170.40	-164.54	-143.01	-105.31	-49.01	26.73	123.87
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-50.72	-126.34	-168.92	-184.82	-178.96	-147.43	-119.73	-63.43	12.31	109.45
	Strategy II Years 1-10: High-level yields										
Gross income		575.87	833.19	1,146.60	1,311.47	1,474.16	1,553.50	1,633.30	1,694.68	1,786.94	1,866.84
less total costs[b]		549.71	719.55	912.30	980.45	1,052.02	1,089.57	1,127.25	1,157.16	1,214.12	1,251.84
Net returns		26.16	113.64	234.30	331.02	422.14	463.93	506.05	537.52	572.82	615.00
less net financial costs		15.88	70.92	36.93	17.26	17.31	17.36	17.41	17.46	17.51	17.55
Net income before taxes		10.28	42.72	197.37	313.76	404.83	446.57	488.64	520.06	555.31	597.45
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-4.14	28.30	182.96	299.34	390.42	432.16	474.22	505.64	540.90	583.04
	Strategy II Years 1-10: Low-level yields										
Gross income		415.43	545.62	694.45	752.43	807.08	844.80	880.32	918.97	956.93	995.68
less total costs[b]		477.03	590.85	711.55	733.14	757.57	775.96	791.59	809.43	826.81	844.61
Net returns		-61.60	-45.25	-17.10	19.29	49.51	68.84	88.73	109.54	130.12	151.07
less net financial costs		15.81	164.65	307.06	429.23	521.03	586.95	635.75	667.77	679.79	670.64
Net income before taxes		-77.41	-209.88	-324.16	-409.94	-471.52	-518.11	-547.02	-558.23	-549.67	-519.57
less taxes		14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42	14.42
Net income after taxes		-91.83	-224.30	-338.58	-424.36	-485.94	-531.53	-561.44	-572.65	-564.09	-533.99

[a] U.S. dollars. [b] Excluding financial charges. [c] Small errors due to rounding.

Additional Requirements

The budget model for the Chilalo case study represents two strategies by which improvements in mechanized agricultural technology may be introduced in the economy of small farmers. It is intended that there should be well-qualified supervisory personnel in the area, adequate storage facilities for cash crop production, and in strategy II adequate equipment available for cultivation and harvesting operations. The costs of these additional requirements are shown in Table B.12. These personnel and equipment are considered to be adequate for 150-200[1] farmers in strategy I and 50 farmers in strategy II forming an operational unit or cooperative. This unit covers an area of about 1,200-1,600 hectares of cultivated land in the case of strategy I and about 400 hectares in strategy II.

Supervision

Two technically competent individuals are to be appointed to the operational unit. Their duties cover demonstrations and guidance in the implementation of improved techniques, distribution of information and improved inputs to farmers, the recording and administration of loan transactions, the supervision of the Hire Service and, in cooperation with the Grain Corporation of Ethiopia, the supervision of storing and marketing cash crops. Some differentiation of duties is envisaged, thus the two appointees are given different titles: Extension Agent and Research Officer.

Equipment

In strategy I, in addition to supervisory, demonstration and recording duties, the operational unit is to be equipped for grain storage. In strategy II, in addition to storage facilities, a complete range of tillage and harvesting equipment is maintained on inventory for hire by farmers in the area (Table B.12).

Additional labor will be necessary in strategy I to store grain during the harvest period and to remove grain from storage for marketing. In strategy II additional personnel will be necessary to maintain the Hire Service: two tractor operators for eight months of the year and two additional driver-laborers to assist in grain transportation

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[1]An arbitrary figure of 175 was used in computations.

TABLE B.12 Chilalo: Estimated annual costs for additional personnel, equipment, and supporting costs for strategy I (150-200 farmers) and strategy II (50 farmers) during budget period (t=0,...,10)

Item	1	2	3	4	5	6	7	8	9	10
	Annual additional costs at indicated year									
	--dollars*--									
	Strategy I (150-200 farmers)									
Personnel										
Salaries[a]	7,200	7,440	7,680	7,920	8,160	8,160	8,400	8,400	8,640	8,640
Per diem	800	800	800	800	800	800	800	800	800	800
Wages[b]	87	87	87	87	87	87	87	87	87	87
Subsistence[c]	8	8	8	8	8	8	8	8	8	8
Total	8,095	8,335	8,575	8,815	9,055	9,055	9,295	9,295	9,535	9,535
Vehicle[d]										
Cost (7% p.a.; 3 yr.)[e]	(1)[f] 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387
Maintenance	400	400	400	400	400	400	400	400	400	400
Fuel	800	800	800	800	800	800	800	800	800	800
Total	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Equipment										
Bins[f] (7% p.a.; 7 yr.)[e]	(6)[g] 445	(10) 742	(14) 1,039	(16) 1,188	(16) 1,188	(18) 1,337	(20) 1,486	(20) 1,041	(22) 893	(22) 596
Augur[h] (7% p.a.; 5 yr.)[e]	(1)[g] 32	(1) 32	(1) 32	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64
Total	477	774	1,071	1,252	1,252	1,401	1,550	1,105	957	660
Repair allowance	13	13	13	26	26	26	26	26	26	26
Total costs	12,372	12,909	13,446	13,880	14,120	14,269	14,658	14,213	14,305	14,008
	Strategy II (50 farmers)									
Personnel										
Salaries & per diem	8,000	8,240	8,480	8,720	8,960	8,960	9,200	9,200	9,440	9,440
Wages[c]	989	989	989	989	989	989	989	989	989	989
Subsistence[c]	49	49	49	49	49	49	49	49	49	49
Total	9,038	9,278	9,518	9,758	9,998	9,998	10,298	10,298	10,478	10,478
Vehicle	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Equipment										
Tractors[j] (7% p.a.; 5 yr.)[e]	(2)[g] 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951	(2) 1,951
Disc plow[k] (7% p.a.; 7 yr.)[e]	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) -	(2) -	(2) -
Disc harrow[l] (7% p.a.; 7 yr.)[e]	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) 297	(2) -	(2) -	(2) -
Planter[m] (7% p.a.; 7 yr.)[e]	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) 445	(2) -	(2) -	(2) -
Grain drill[n] (7% p.a.; 7 yr.)[e]	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) 586	(2) -	(2) -	(2) -
Tool bar[o] (7% p.a.; 7 yr.)[e]	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) 74	(2) -	(2) -	(2) -
Cultivator[p] (7% p.a.; 7 yr.)[e]	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) 259	(2) -	(2) -	(2) -
Combine[q] (7% p.a.; 5 yr.)[e]	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244	(1) 2,244
Corn sheller[r] (7% p.a.; 5 yr.)[e]	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) 74	(1) -	(1) -	(1) -
Trailer[s] (7% p.a.; 5 yr.)[e]	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) 148	(2) -	(2) -	(2) -
Bins[t] (7% p.a.; 5 yr.)[e]	(6) 442	(10) 742	(14) 1,039	(16) 1,188	(18) 1,337	(20) 1,486	(22) 1,635	(22) 1,190	(24) 1,042	(24) 745
Augur[u] (7% p.a.; 5 yr.)[e]	(1) 32	(1) 32	(1) 32	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64
Total	6,849	7,149	7,446	7,627	7,776	7,925	8,074	5,449	5,301	5,004

Operating costs[v]	2,909	2,090	2,909	2,922	2,922	2,922	2,922	2,922	2,922	2,922
Total cost	22,583	23,123	23,660	24,094	24,483	24,632	25,081	22,456	22,488	22,191
Total costs less returns from hire-service										
High-level yields	13,511	12,079	10,641	11,084	11,411	11,539	11,966	9,318	8,612	8,291
Low-level yields	13,511	12,079	10,641	11,084	11,411	11,539	11,966	9,318	9,333	9,017

*U.S. dollars

[a]Extension Agent and Research Officer paid equally.

[b]Two laborers ($0.60 per day) employed for three months.

[c]Laborers' and drivers' food allowance: $0.10 per day.

[d]Land Rover @ $3,640 each acquisition price.

[e]Amortization charge; rate in parenthesis to each item. Period of amortization adjusted to effect loan repayment within depreciation period. Annual depreciation rates: vehicles, 33%; tractors, combines, augurs, 20%; cultivating equipment, 10%; bins, 5%.

[f]Bins: capacity, 500 quintals; @ $400 each.

[g]Number of equipment units contained in parenthesis.

[h]Augur: 6" dia., 3 h.p. engine; @ $130 each.

[i]One driver-mechanic and one driver employed for eight months plus two additional drivers during harvest time at $48.00 per month each; two laborers for one month at $0.60 per day each.

[j]Tractors: 45 h.p. @ $4,000 each.

[k]Plow: 3 furrow disc @ $800 each.

[l]Disc harrow: 3 disc (7 m. wide) @ $800 each.

[m]Planter: 4 row @ $1,200 each.

[n]Drill: 3.7 m. wide @ $1,580 each.

[o]Tool bar: $200 each.

[p]Cultivator: 2 row @ $700 each.

[q]Combine: 3.7 m. wide @ $9,200 each.

[r]Sheller: power-take-off @ $400 each.

[s]Trailer: 9 metric ton @ $400.

[t]Bins as in strategy I.

[u]Augur as in strategy I.

[v]Fuel/allowance $300 per tractor and $300 for combine; repair and maintenance 6.5% on capital investment-costs.

Source: U.S. Agency for International Development, Shashamanne Farm Development Project . . ., pp. 32-33, A.i-vi.

and storage during the two months of combining; two laborers are to be hired for a total of one month each to assist in dispatching grain to market. One of the tractor drivers should have sufficient mechanical skills to perform field maintenance and repair work.

Infrastructure

Asela and the surrounding area of Chilalo is already served by a major road. Farm roads are extremely rough but passable for agricultural equipment. Much needs to be done to improve the feeder road system. General improvements in road facilities throughout the Empire are anticipated in the Ethiopian Third Five-Year Development Plan.[1]

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[1]Imperial Ethiopian Government, Third Five-Year Plan . . ., p. 46.

APPENDIX C

SETIT-HUMERA CASE STUDY

APPENDIX C

SETIT-HUMERA CASE STUDY

Introduction

The third case lies in the remote Province of Begemdir and Simen close to the Sudanese border about 750 kilometers northwest of Addis Abeba. The Setit-Humera area, lying between the Setit and Angareb Rivers, is roughly divisible into two parts: 350,000 hectares bounded by the Tekeze River, the northern branch of the Angareb River, the Sudanese border and longitude 37° East; and 150,000 hectares lying south of the northern branch of the Angareb River, bounded by the Sudanese border and longitude 37° East. The first area, at an elevation of 600 meters, consists of 175,000 hectares farmed entirely by tractor and another 52,000 hectares of useful land not yet being farmed; the second area, at an elevation between 600 and 1,000 meters, consists of 30,000 hectares of useful farmland of which less than 1 per cent is farmed. Farming in second area is entirely by oxen. Humera (location: 14°20' North, 37°60 East) on the Tekeze River is the principal town of the area.

Recently, the area has been developed primarily by private entrepreneurs using modern engine-powered equipment although a large number of oxen farmers with small farms of six to eight hectares have settled in the fringes of the area during the past 50 years. Concessions of land, hitherto unsettled and uncultivated, have been relatively easy to obtain through the local vice-governor's office. The area of concessions vary from 400 to 1,000 hectares (the first one was 7,000 hectares, on a 70-year lease); no titles, other than leases, have been granted.

The soils are described as vertisols (self-mulching, black cotton soil) containing about 50 per cent clay.[1] African soils of this classification are among the

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[1]Kline, *et al.*, *op. cit.*, Pt. II, p. 135.

best soils for growing cotton, maize, wheat, sorghum, oilseeds, rice, tobacco, fodder crops and pasture grasses.[1]

No irrigation is practiced despite its proximity to the Tekeze River. The surrounding farmland is considerably higher than the river, irrigation pumping would be a costly operation. Local agriculture depends entirely on annual rainfall which is a major limiting factor. Rainfall data is recorded in Table C.1.

The Setit-Humera area is of considerable interest to the Imperial Ethiopian Government and development agencies because of its high economic potential. A large number of migrant laborers are employed annually by the farmers although there is also extensive employment of engine power in the cultivation operations. Economic expansion in the area has been rapid and unplanned over the past ten years. Supportive infrastructure has not been adequately developed. Facilities for the provision of drinking water, housing, transportation, communication and medical services are all poor. There are shortages of storage facilities, credit accommodation, labor and general agricultural services.[2] At present the inadequately developed infrastructure is a serious threat to economic expansion of the Setit-Humera area.

This case study has been prepared from observations made in the area during the 1968-69 season (t=0) and data published by the Institute of Agricultural Research.[3] Supplementary data for the many assumptions were obtained largely from materials published by Stanford Research Institute.[4]

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[1]Report of the Survey Mission on the Agricultural Development of Setit-Humera, 31 October-3 November, 1967 (Addis Abeba: Institute of Agricultural Research, December, 1967), pp. 10-11.

[2]Ibid., p. 6. [3]Ibid.

[4]Carl F. Miller, et al., Systems Analysis Methods . . . .

TABLE C.1 Setit-Humera: Climatic data and distribution of crop operations by calendar months, budget model initiating year (t=0)

Item	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Season	----------	----------	----------	----Dry----	----------	----------	----------	----------	----------	----Wet----	----------	----------
Mean rainfall[a] (mm.)	-	-	-	-	5.0	24.1	64.7	189.7	217.3	100.4	11.7	2.5
Mean temperature[a] (°C)	26.7	25.5	26.4	29.0	32.1	32.4	31.0	28.1	26.7	28.1	29.8	28.7
<u>Crop operations in current practice</u>[b]												
Sesame						disc, plant			weed			harvest
Cotton		pick					disc, plant				weed	
Grain sorghum			harvest					disc, plant				weed

[a]Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 66.

[b]*Report of the Survey Mission . . .*, pp. 18-21.

Present Agricultural Economy

The People and Their Habitat

Currently, the area is one of rapid, unplanned expansion. Experienced and inexperienced farmers have been able to obtain land with relative ease and have established homesteads throughout the area.

Some 60,000 migrant workers come into the area annually for employment during the planting and weeding season beginning in May and for the harvest season beginning in October. Farmers have built simple forms of accommodation on their farms for their labor force.

Humera, with a population of 20,000 in 1967, is the local market and trading center as well as the center for administration, security and law enforcement. The town is the collection and storage point for agricultural produce to be transported to Asmera, the principal market, some 430 kilometers east. Since there is no local marketing organization, most farmers are obliged to sell their crops to local merchants to whom they are heavily indebted by harvest time. Larger and more progressive farmers sell in Asmera. Transportation involves double handling because no bridge exists over the Tekeze River. Tractors are only able to haul produce across the river during the period January through May, and the road connection to the main all-weather route from Asmera to Tessenei is only passable for trucks during the dry season.[1] Farm roads and main roads within the area are extremely poor.[2]

Until settlement began some ten years ago, there was no indigenous population other than nomadic herdsmen and camel caravan drovers. Thus, the area is virgin agricultural country in which the number of scattered farmsteads is gradually increasing.

The average size of farm is 800 hectares. Under present conditions one tractor is sufficient to farm about 40 hectares; one tractor is required for hauling water and for general transportation.[3] Thus, many farms of this average size are likely to use three tractors. Three tractors appear to be more useful than two tractors and a Land Rover since one additional tractor is available for the early tillage operations and is used for general

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[1] _Ibid._, p. 13-14. [2] _Ibid._ [3] _Ibid._, p. 25.

haulage and transport for the rest of the year; the farmer can make long distance journeys by grain truck or by the bus service.[1]

Agricultural Practices

In the initiating year (t=0), the distribution of crops was observed to be: grain sorghum, 45 per cent; sesame, 30 per cent; cotton, 25 per cent. This year of observation followed a substantial decline in the market price of grain sorghum in Asmera and, consequently shows a marked decline from the proportions of crops observed by the Mission from the Institute of Agricultural Research which reported crop dispositions for the 1967-68 season as grain sorghum, 55 per cent; sesame, 16 per cent; cotton, 29 per cent. The cropping pattern appears to be quite sensitive to changes in market prices.

Usually each farmer grows all three crops each year. No particular pattern of rotation is followed; when an area becomes weedy grain sorghum, which tends to compete against weeds more successfully, is planted in the following season. Fallow cultivation is not practiced. Crop areas are determined on the basis of market considerations with the exception of grain sorghum which is both the important subsistence crop of the area and an important cash crop; therefore the area of sorghum grown is determined by both market considerations and local consumption requirements.

Despite the current dependence of farmers on hand labor a wide variety of tractor equipment is also employed in the area.[2] The annual capital inventories are shown in Table C.2(a). The principal cultivation implement is the wide-level disc harrow (18-24 discs).

Data presented throughout this case study are for two strategies, the basic differences between these two strategies are depicted in Table C.2(a). In strategy I less tractor equipment is employed than in strategy II: all planting, weeding, thinning, spraying, harvesting and clearing operations are to be performed by hand in strategy I; tractor equipment is to be employed for some of the crops in planting, cultivating, and clearing operations, and grain sorghum is to be harvested by combine in strategy II.

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[1] *Ibid.*, p. 14. [2] *Ibid.*, p. 24.

TABLE C.2 Setit-Humera: Basic assumptions
a. Total annual cost of capital inventory in operation[a] for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Item	Annual capital cost at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[b]										
	Strategy I										
Tractor equipment[c]	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,220	17,200
Sprayers[d]		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Hand tools[e]	378	567	587	590	596	599	603	606	610	614	614
Grain bins[f]		1,800	1,800	1,800	1,800	1,800	1,800	2,000	2,000	2,000	2,000
Total	17,598	22,587	22,607	22,610	22,616	22,619	22,623	22,826	22,830	22,834	22,834
	Strategy II										
Tractor equipment[g]		20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720	20,720
Combine		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Sprayers		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Hand tools		416	437	455	461	464	468	470	473	473	473
Grain bins		1,400	1,400	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
Total		37,536	37,557	37,775	37,781	37,784	37,788	37,790	37,793	37,793	37,793

[a]Equipment in current operation, and not fully depreciated, valued at acquisition price.

[b]All dollar values for these analyses are U.S. dollars.

[c]Three 65-75 h.p. wheel tractors @ $4,200 each; three wide-level disc harrows (24 discs) @ $940 each; two 3-ton trailers @ $900. Tractor equipment depreciated at 10 per cent of acquisition per annum.

[d]Thirty back-pack sprayers @ $100 each. Depreciated at 25 per cent of acquisition cost per annum.

[e]Hand-hoes for weeding and cultivating over a period of 156 working days and sickles for hand harvesting grain sorghum and sesame over 212 working days. Tools valued at $1.80 each and depreciated at 10 per cent of acquisition cost per annum.

[f]Capacity 200 quintals each for storing grain sorghum required for local food supply. Valued at $250 each and depreciated at 10 per cent of acquisition price per annum.

[g]Equipment used in strategy I plus one seed planter @ $1,160; one cultivator @ $1,300; one rotary slasher @ $1,040.

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., p. 98.

TABLE C.2 Continued
b. Price and annual yield assumptions, budget model (t=0,...,10)

Crop	Variety	Production level	Price	Annual yield at indicated year: 0	1	2	3	4	5	6	7	8	9	10
			$/q.[a]	---	---	---	---	quintals per hectare	---	---	---	---	---	---
Sesame	Morado	H[b]	20.15	6.0[d]	6.3[e]	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0
		L[c]			6.2	6.3	6.5	6.7	6.8	7.0	7.2	7.4	7.5	7.7
Cotton	Acala 1517 or 4.42	H	25.00	3.0[d]	3.4[e]	3.9	4.3	4.8	5.2	5.7	6.1	6.6	7.0	7.5
		L			3.2	3.4	3.4	3.9	4.1	4.3	4.6	4.8	5.0	5.3
Grain sorghum		H	4.84	15.0[d]	15.5[e]	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
		L			15.2	15.5	15.8	16.0	16.2	16.5	16.8	17.0	17.2	17.5
Haricot beans	Negro Mecentral	H	9.60	-	8.0[f]	9.3	10.6	11.9	13.3	14.6	15.9	17.3	18.6	20.0
		L			8.0	8.6	9.3	10.0	10.6	11.3	12.0	12.6	13.3	14.0

[a] U.S. dollars. [b] High-level yields. [c] Low-level yields.

[d] Based on field observations: Report of the Survey Mission . . ., p. 31.

[e] Improved yields based on estimated attainable yields under improved cultivation practices: Carl F. Miller, *et al.*, Systems Analysis Methods . . ., p. 289.

[f] Yield possibility for haricot (dry) beans calculated from combined production function: $Y = Y_m \prod_{i=1}^{7} \phi_i$

where: $\phi_2 \cdot \phi_3 = (2-T/T_m)(2-R/R_m)(T/T_m)(R/R_m)$, $T=28.67$, $T_m=20$, $R=.051279$, $R_m=.120$;

$\phi_4 \cdot \phi_5 \cdot \phi_6 = .792$;

$\phi_7 = .8$;

and $Y_m = 66.6$.

Ibid., pp. 119-203.

TABLE C.2 Continued
c. Cultivation practices for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Operation	Number of operations in initiating year for indicated crop			Number of operations in each year of strategy I for indicated crop				Number of operations in each year of strategy II for indicated crop			
	Sesame	Cotton	Sorghum	Sesame	Cotton	Sorghum	Beans	Sesame	Cotton	Sorghum	Beans
	number of operations										
Disc plow											
--mechanical	2	2	2	2	2	2	2	2	2	2	2
Plant--hand	1	1	1	1	1	1	1	1	-	-	1
--mechanical	-	-	-	-	-	-	-	-	1	1	-
Disc plow											
--mechanical	1	1	1	1	1	1	1	-	-	-	-
Cultivate											
--hand	-	1	1	1	1	1	1	1[a]	-	-	1[a]
--mechanical	-	-	-	-	-	-	-	-	2	2	-
Weed & thin											
--hand	2	2	1	2	2	1	2	1[a]	1[a]	-	1[a]
Spray--hand	-	-	-	1	-	1	1	1[a]	-	1[a]	1[a]
--aerial	-	-	-	-	3	-	-	-	3	-	-
Harvest											
--hand	1	2-3	1	1	2-3	1	1	1	2-3	-	1
--mechanical	-	-	-	-	-	-	-	-	-	1	-
Thresh &											
winnow--hand	1	-	1	1	-	1	1	1	-	-	1
Clear--hand	1	1	1	1	1	1	-	1	-	1	-
--mechanical	-	-	-	-	-	-	-	-	1	-	-

[a]These hand operations are maintained in order to retain hand labor force in occupation until harvesting begins.

Source: Carl F. Miller et al., Systems Analysis Methods . . ., pp. 242-43.

TABLE C.2 Continued
d. Estimated costs for manual and machine operations, budget model (t=0,...,10)

Operation	Manual and machine crop[a] operation according to indicated straqegy				Manual operation		Machine operations	
	Strategy I		Strategy II					
	Manual	Machine	Manual	Machine	Rate	Cost	Rate	Cost
					man-days/ha.	$/day[b]	machine-days/ha.	$/day[b]
Discing	-	all	-	all	-	-	.1667	24.83[c]
Planting	all	-	S,B	C,Sm	5.0	.80	.10	28.08
Cultivating	-	-	S,B	C,Sm	20.0	.60	.125	22.72
Weeding & thinning	all	-	S,C,B	-	13.4	.60	-	-
Spraying	all	-	S,Sm,B	-	1.0	.60	-	-
Clearing	S,C,Sm	-	S,Sm	C	20.0	.60	.125	26.20
Harvesting	S	-	S	-	$28.00/ha	.60	-	-
	C	-	C	-	$ 2.00/q.	.60	-	-
	Sm	-	-	Sm	$ .60/q.	.60	.0705[d] / .0941	66.76
	B	-	B	-	$ 4.00/ha.	.60	-	-
Threshing & winnowing	S	-	S	-	$ .80/q.	.60	-	-
	Sm	-	-	-	$ .40/q.	.60	-	-
	B	-	B	-	$ .60/q.	.60	-	-

[a]Sesame = S, Cotton = C, Grain Sorghum = Sm, Haricot beans = B.

[b]U.S. dollars.

[c]Machine costs calculated from data which included capital recovery charges (published by Stanford Research Institute). This budget model includes depreciation as an operating charge, therefore capital recovery charge included in original data has been deducted.

[d]Combine operating rate reduced for heavy crop yields: 14.175 ha./day (.0705 days/ha.) if Y_{X_i} < 31.36 q/ha., 10.63 ha./day (.0941 days/ha.) if $Y_{X_i} \geq$ 31.36 q/ha.

Source: Carl F. Miller, et al., Systems Analysis Methods . . ., pp. 98-99.

In terms of equipment, there is no change in strategy I from already established inventories of equipment. The change from current practice lies in cultivation practices to be discussed later. In strategy II there are changes both in cultivation practices and in equipment to handle the productive processes.

Crop yields for the initiating year are recorded in Table C.2(b). The differences in cultivation practices between strategy I (t=1,...,10), strategy II (t=1,...,10) and the current practice observations for the initiating year (t=0) are set out in Table C.2(c).

Production and Value of Crops

Until 1967 grain sorghum had been the major cash crop of Setit-Humera area when prices for grain sorghum fell dramatically to $4.6[1] in April, 1968. This fall led to a readjustment in the allocation of land in the 1968-69 season. Farmers anticipated little change in relative prices for the forthcoming season and anticipated a general movement in the area out of grain sorghum production into sesame and cotton production. Thus, the initiating year of the budget model has been established on the basis of average seasonal crop prices for the 1967-68 season.[2] These prices are recorded in Table C.2(b).

The quantity of grain sorghum consumed by the laboring population has been calculated on the basis of a basic requirement of .018 quintals per man-day of work[3] constituting the non-cash portion of the wage payment. The quantity of grain sorghum required by the labor force constitutes a minimum constraint to the farmer in planning the disposition of crops from one season to the next.

Estimated costs of manual and machine operations are recorded in Table C.2(d). During most of the season manual labor is currently employed at $0.60 per day for an eight-hour day; for hand planting (broadcasting) which tends to be more intensive work and for a longer working day (8-10 hours), $0.80 per day is paid currently. Tractor

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[1]All dollar values are U.S. dollars.

[2]*Ibid.*, p. 39.

[3]Assuming a six-day week this rule of thumb is approximately the same as that used for Agnale Village.

drivers receive the equivalent of $2.00 per day.[1] During harvesting different arrangements are currently established for different crops: sesame is harvested by contract on the basis of area to a harvest-gang leader; cotton and grain sorghum are harvested by payment on the basis of weight to individual harvesters.

Technological Improvements

Mechanized agricultural technology is established from the beginning in this case study. Thus, technological improvements are directed toward improvements in cultivation techniques, the development of new varieties, and control of insect pests. Improvements in infrastructure, much needed for the economic development of this area, are to be discussed below.

Hand Tools

No change has been anticipated in the type or design of hand tools employed. Two tools are widely used, the hoe for weeding and cultivating and the sickle for harvesting. These tools are similar to those described for Chilalo. The number of hand tools required were estimated for the capital inventories recorded in Table C.2(a) on the basis of man-days of manual labor required during the cropping season.

Grain Storage

Farmers store on the farm only that portion of the grain sorghum crop required as food for hired laborers. All other crops are hauled by tractor to Humera and across the river to be loaded onto trucks for transportation to Asmera. Grain sold to merchants in Humera is kept in a wide variety of storage places until merchants are able to find tractor haulage across the river to the truck loading point.

Wastage on the farm has been assumed to be in the region of 15 per cent in the initiating year. With the introduction of improved storage bins wastage has been reduced to 3 per cent in the operational years (t=1,...,10) of the budget model.

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[1] Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 99.

Crop Yields and Areas

Assumed levels of crop yields for the budget model are shown in Table C.2(b). Assumed yields for sesame, cotton, and grain sorghum are an approximation of those suggested as obtainable[1] by using the improved cultivation practices shown in Table C.2(d). These approximations were determined by taking into account other observations on yield possibilities in the area.[2] Assumed yields for haricot beans were calculated by using the combined production function already discussed in the Agnale case study. The determined maximum yield is close to that suggested as being attainable[3] under improved cultivation practices.

Maximum attainable yield has been assumed for each crop in the final year (high-level) of the budget model; annual yield increments are equal. Low-level yields were arbitrarily assumed to be approximately three-quarters of the maximum attainable yields.

In this case study the farmer takes crop profitability into account in deciding the area of each crop to be grown each season. The decision involves crop yields, anticipated market prices and production costs. As in the Chilalo case study, a simple decision-making algorithm was built into the budget model in order to determine crop areas year by year. The algorithm was based on farmers' responses in interview that the decision of how many hectares of a crop to grow was made on the basis of its profitability in the preceding year. Profitability appeared to be determined in the farmer's mind as an operating margin of gross income less direct costs for each crop.

In the model the procedure is: first, for the year preceding the current season, to determine the operating margin (per unit area) on each crop and the average operating margin (per unit area) for all crops; second, for the current season, to increase the area of those crops which are more profitable than the average in proportion to their profitability: the total increase in the area of more

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[1] Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 289.

[2] *Report of the Survey Mission . . .*, pp. 21-23.

[3] 26.6 quintals per hectare: Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, p. 289.

profitable crops is than spread as a deduction from the area of those crops which are less then average profitability, in proportion to their profitability. One specific and two general constraints operate. The specific constraint fixes the minimum level of area sown to sorghum so that the farmer has a sufficient supply of grain for his laborers. The quantity of sorghum required in the current season is determined as 10 per cent above the requirements of the preceding year. The figure of 10 per cent is an arbitrary margin which was found to cover these basic subsistence requirements adequately as cropping areas are adjusted. The two general constraints limit the total adjustment of any one crop to a maximum of 20 per cent increase or decrease over the preceding year, and the minimum area for any one crop is fixed at 50 hectares. These two general constraints are included to prevent violent shifts in crop areas from one season to the next and to prevent the entire area adjusting to a single crop.[1]

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[1]The decision-making algorithm to determine the distribution of total area among four different crops is defined as follows:

<u>Variables (X_i)</u>

Crop yield: Y_{X_i}, i=1,...,4 (decisions based on high-level yields)

Total area for individual crops: A_{X_i}

Physical outputs (per hectare)--sesame, cotton, sorghum, beans: i=1,...,4 (quintals)

Physical inputs (per hectare)--machine time for each crop: i=5,...,8 (machine-days)
--labor for each crop: i=9, ...,12 (man-days)
--seeds for each crop: i=13, ...,16 (quintals)
--spray for each crop: i=17, ...,20 (liters)
--sacks for each crop: i=21, ...,24 ($X_i=Y_{X_i}$ for i=21, ...,24)
--handling and transport for each crop: i=25,...,28 (quintals of crop to be transported)

Other values--subsistence requirement of sorghum: H_{X_3}
--waste level: W_{X_i} (per cent)
--prices: P_{X_i} (dollars per unit)

<u>Average margin (per hectare) for all crops ($\bar{m}_X$)</u>

$$\bar{m}_{X(t)} = \frac{\sum_{i=1}^{4} (A_{X_{i(t)}} \cdot Y_{X_{i(t)}}) P_{X_{i(t)}} - \sum_{i=5}^{28} X_{i(t)} P_{X_{i(t)}}}{\sum_{i=1}^{4} A_{X_{i(t)}}}$$

<u>Margin (per hectare) for individual crops (m_{X_i})</u>

$$m_{X_{1(t)}} = \left[(A_{X_{1(t)}} \cdot Y_{X_{1(t)}}) P_{X_{1(t)}} - \sum_{i=5,9,13,17,21,25} X_i P_{X_i} \right] \Big/ A_{X_{1(t)}}$$

$$m_{X_{2(t)}} = \left[(A_{X_{2(t)}} \cdot Y_{X_{2(t)}}) P_{X_{2(t)}} - \sum_{i=6,10,14,18,22,26} X_i P_{X_i} \right] \Big/ A_{X_{2(t)}}$$

$$m_{X_{3(t)}} = \left[(A_{X_{3(t)}} \cdot Y_{X_{3(t)}}) P_{X_{3(t)}} - \sum_{i=7,11,15,19,23,27} X_i P_{X_i} \right] \Big/ A_{X_{3(t)}}$$

$$m_{X_{4(t)}} = \left[(A_{X_{4(t)}} \cdot Y_{X_{4(t)}}) P_{X_{4(t)}} - \sum_{i=8,12,16,20,24,28} X_i P_{X_i} \right] \Big/ A_{X_{4(t)}}$$

<u>Constraints</u>

1. $\frac{|A_{X_{i(t-1)}} - A_{X_{i(t)}}|}{A_{X_{i(t-1)}}} \not> \cdot 2$

2. $A_{X_i}(\min)_{(t)} = 50$ for $i=1,2,4$

3. $A_{X_3}(\min)_{(t)} = \left[\frac{(A_{X_{3(t-1}})1.1}{1-W_{X_{3(t-1)}}} \right] \Big/ Y_{X_{3(t)}}$

Labor Utilization

The rates for labor utilization are set out in Table C.2(d). Since the labor force in the area has already 10 years experience of these operations, and since no change in hand tools is envisaged, the level of efficiency in these operations has been held constant. Increases in labor requirements in the operational years of the budget model are due to increasing the intensity of manual operations in the improved cultivation practices shown in Table C.2(c).

Crop Protection

Weeds and insect pests are the major production problems of the area.[1] Improved cultivation practices are designed to reduce weed infestation thereby facilitating improved crop yields. Recommended cultivation practices

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<u>Areas (for both strategies)</u>

1. For X_i where $m_{X_{i(t-1)}} > \bar{m}_{X(t-1)}$

$$A_{X_{i(t)}} = \left(A_{X_{i(t-1)}}\right)\left[\frac{m_{X_{i(t-1)}}}{m_{X(t-1)}}\right]$$

2. For X_i where $m_{X_{i(t-1)}} \leq \bar{m}_{X(t-1)}$

$$A_{X_{i(t)}} = A_{X_{i(t-1)}} - \left[\left[\begin{array}{l} \Sigma A_{X_{i(t)}} - \Sigma A_{X_{i(t-1)}} \\ \text{for all } i \text{ where} \\ m_{X_{i(t-1)}} > \bar{m}_{X(t-1)} \end{array}\right]\left[\begin{array}{l} \dfrac{m_{X_{i(t-1)}}}{\Sigma m_{X_{i(t-1)}}} \\ \text{for all } i \text{ where} \\ m_{X_{i(t-1)}} \leq \bar{m}_{X(t-1)} \end{array}\right]\right].$$

[1] <u>Report of the Survey Mission . . .</u>, pp. 26-30.

for Setit-Humera[1] include an insecticide spraying program for each crop. In the budget model, sesame, cotton, and sorghum are to be sprayed once by hand. Hand spraying has been employed because while the farmers must keep a large labor force for weeding and harvesting, a lull occurs in the work requirements between these operations during which the farmer must retain the laborers in order not to lose them as demand suddenly surges for harvesters.

Insect pests of cotton are a very serious threat to the crop, and therefore, three aerial sprayings are incorporated into the plan of improved cultivation practices. These sprays must be applied promptly when they are required and an air spray service is the only practical solution to avoid serious crop damage.

Budgets

Outputs and Inputs

Data contained in Table C.2 are the basic assumptions on which the budget model has been prepared. Table C.3 contains the high-level annual income accounts for strategy I and the corresponding annual input accounts are contained in Table C.4.

Summaries of output and input data for both strategies and both production levels are contained in subsequent tables. Table C.5 contains annual areas and the summary of total physical production for each crop; Table C.6 contains a summary of annual incomes.

Input data are contained in the three following tables. Table C.7 contains the annual distribution of labor used in field operations; Table C.8 contains the inputs of seed, spray, and transport requirements; Table C.9 contains a summary of annual total costs for inputs (excluding financial charges).

Depreciation rates are recorded in Table C.2(a). As with the previous case studies, the purchase of capital equipment has been assumed possible through medium-term loan accommodations. Therefore, the depreciation charge represents an accumulated cash fund which has been applied to defray annual financial charges to the farm.

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[1]Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, pp. 242-43.

TABLE C.3 Setit-Humera: Annual income accounts, budget model (t=0,...,10)--strategy I, high-level yields, years 1-10

Year	Crop	Area	Yield	Production	Non-cash product	Cash product	Gross income
		hectares	q/ha.	quintals	dollars[a]		
0	Sesame	240	6.0	1,440.00	-	29,016.00	29,016.00
	Cotton	200	3.0	600.00	-	15,000.00	15,000.00
	Sorghum	360	15.0	5,202.63[b]	5,413.12	19,767.63	25,180.74
	Total	800			5,413.12	63,783.63	69,196.74
		Strategy I Years 1-10: High-level yields					
1	Sesame	413	6.3	2,601.90	-	52,428.28	52,428.28
	Cotton	137	3.4	465.80	-	11,645.00	11,645.00
	Sorghum	150	15.5	2,275.00	7,824.56	3,186.44	11,011.00
	Beans	100	8.0	800.00	-	7,680.00	7,680.00
	Total	800			7,824.56	74,939.73[c]	82,764.29[c]
2	Sesame	446	6.6	2,943.60	-	59,313.54	59,313.54
	Cotton	154	3.9	600.68	-	15,015.00	15,015.00
	Sorghum	120	16.0	1,868.36	8,080.86	962.02	9,042.88
	Beans	80	9.3	744.00	-	7,142.40	7,142.40
	Total	800			8,080.86	82,432.96	90,513.82
3	Sesame	455	6.9	3,139.50	-	63,260.92	63,260.92
	Cotton	163	4.3	701.90	-	17,522.50	17,522.50
	Sorghum	118	16.5	1,894.67	8,189.32	980.89	9,170.20
	Beans	64	10.6	678.40	-	6,512.64	6,512.64
	Total	800			8,189.32	88,276.95	96,466.27
4	Sesame	462	7.2	3,326.40	-	67,026.90	67,026.96
	Cotton	171	4.8	820.80	-	20,520.00	20,052.00
	Sorghum	116	17.0	1,119.02	8,290.85	997.21	9,288.06
	Beans	51	11.9	606.90	-	5,826.24	5,826.24
	Total	800			8,290.85	94,370.41	102,661.26
5	Sesame	463	7.5	3,472.50	-	69,970.87	69,970.87
	Cotton	173	5.2	899.60	-	22,490.00	22,490.00
	Sorghum	114	17.5	1,941.62	8,353.82	1,043.62	9,397.43
	Beans	50	13.3	665.00	-	6,384.00	6,384.00
	Total	800			8,353.82	99,888.49	108,242.31
6	Sesame	464	7.8	3,619.20	-	72,926.88	72,926.88
	Cotton	174	5.7	991.80	-	24,795.00	24,795.00
	Sorghum	111	18.0	1,944.18	8,422.44	987.39	9,409.83
	Beans	51	14.6	744.60	-	7,148.16	7,148.16
	Total	800			8,422.44	105,857.43	114,279.87
7	Sesame	465	8.1	3,766.50	-	75,894.97	75,894.97
	Cotton	175	6.1	1,067.50	-	26,687.50	26,687.50
	Sorghum	109	18.5	1,962.23	8,492.71	1,004.49	9,497.20
	Beans	52	15.9	826.80	-	7,937.28	7,937.28
	Total	801			8,492.71	111,524.24	120,016.95
8	Sesame	466	8.4	3,914.40	-	78,875.16	78,875.16
	Cotton	176	6.6	1,161.60	-	29,040.00	29,040.00
	Sorghum	107	19.0	1,978.24	8,569.55	1,005.13	9,574.68
	Beans	53	17.3	916.90	-	8,802.42	8,802.24
	Total	802			8,569.55	117,722.53	126,292.08
9	Sesame	465	8.7	4,045.50	-	81,516.82	81,516.82
	Cotton	178	7.0	1,246.00	-	31,150.00	31,150.00
	Sorghum	105	19.5	1,992.40	8,622.06	1,021.18	9,643.24
	Beans	54	18.6	1,004.40	-	9,642.24	9,642.24
	Total	802			8,622.06	123,330.24	131,952.30
10	Sesame	459	9.0	4,131.00	-	83,239.65	83,239.65
	Cotton	182	7.5	1,365.00	-	34,125.00	34,125.00
	Sorghum	103	20.0	2,004.00	8,655.64	1,047.06	9,702.70
	Beans	58	20.0	1,160.00	-	11,136.00	11,136.00
	Total	802			8,655.64	129,547.71	138,203.35

[a] U.S. dollars.

[b] Waste of 15 per cent reduced to 3 per cent in improved grain bins after t=0.

[c] Small errors in additions are due to calculated values being rounded to 2 decimal places.

TABLE C.4 Setit-Humera: Annual input accounts, budget model (t=0,...,10)--strategy I, high-level yields, years 1-10

Year	Crop	Tractor[a] Non-cash	Tractor[a] Cash	Labor Non-cash	Labor Cash	Seeds Cash	Spray Cash	Sacks Cash	Transport[b] Cash	Clearing Cash	Depreciation Cash	Total inputs Non-cash	Total inputs Cash	Total inputs Total
		dollars[c]												
0	Sesame	24.00	2,956.19	2,555.20	13,016.00	108.84	-	1,267.20	2,880.00	1,257.60	794.94	2,579.20	22,280.77	24,859.97
	Cotton	20.00	2,463.49	1,276.00	6,580.00	226.56	-	270.00	1,320.00	1,048.00	662.45	1,296.00	12,570.50	13,866.50
	Sorghum	36.01	4,434.29	2,354.40	12,132.00	145.08	-	3,780.00	7,351.60	1,886.40	1,192.41	2,390.41	30,921.78	33,312.19[c]
	Total	80.02[d]	9,853.97	6,185.60	31,728.00	480.48	-	5,317.20	11,551.60	4,192.00	2,649.80	6,265.62[c]	65,773.05	72,038.66[c]
	Strategy I Years 1-10: High-level yields													
1	Sesame	41.31	5,087.11	5,280.89	26,817.47	330.40	1,486.80	2,289.67	5,203.80	2,164.12	1,398.37	5,322.20	44,777.74	50,099.94
	Cotton	13.70	1,687.49	892.33	4,598.63	219.20	1,972.80	209.61	1,024.76	717.88	463.86	906.03	10,894.23	11,800.26
	Sorghum	15.00	1,847.62	1,008.50	5,192.50	132.00	540.00	1,62[illegible]	1,185.04	786.00	507.88	1,023.50	11,818.54	12,842.04
	Beans	10.00	1,231.75	674.67	3,473.33	144.00	360.00	624.00	1,600.00	524.00	338.59	684.67	8,295.67	8,980.34
	Total	80.02	9,853.97	7,856.39	40,081.93	825.60	4,359.60	4,750.78	9,013.60	4,192.00	2,708.70	7,936.40	75,786.19	83,722.59
2	Sesame	44.61	5,493.59	5,720.69	29,049.47	356.80	1,605.60	2,590.37	5,887.20	2,337.04	1,511.20	5,765.30	48,831.27	54,596.57
	Cotton	15.40	1,896.89	1,028.72	5,297.60	246.40	2,217.60	270.27	1,321.32	806.96	521.81	1,044.12	12,578.85	13,622.97
	Sorghum	12.00	1,478.10	816.80	4,204.00	105.60	432.00	1,344.00	357.77	628.80	406.60	828.80	8,956.87	9,785.67
	Beans	8.00	985.40	550.13	2,830.67	115.20	288.00	580.32	1,488.00	419.20	271.07	558.13	6,977.86	7,535.99
	Total	80.02	9,853.97	8,116.35	41,381.73	824.00	4,543.20	4,784.96	9,054.29	4,192.00	2,710.68	8,196.36	77,344.84	85,541.20
3	Sesame	45.51	5,604.45	5,854.33	29,726.67	364.00	1,638.00	2,762.76	4,018.56	2,384.20	1,541.91	5,899.84	48,040.55	53,940.39
	Cotton	16.30	2,007.75	1,110.57	5,715.87	260.80	2,347.20	315.40	981.26	854.12	552.37	1,126.87	13,034.77	14,161.64
	Sorghum	11.80	1,453.46	813.02	4,183.10	103.84	424.80	1,362.90	218.88	618.32	399.88	824.82	8,765.18	9,590.00
	Beans	6.40	788.32	448.43	2,306.13	92.16	230.40	529.15	868.35	335.36	216.86	545.83	5,366.75	5,821.58
	Total	80.02	9,853.97	8,226.35	41,931.77	820.80	4,640.40	4,970.22	6,087.05	4,192.00	2,711.04	8,306.37	75,207.24	83,513.61
4	Sesame	46.21	5,690.67	5,962.88	30,276.40	369.60	1,663.20	2,927.23	4,257.79	2,420.80	1,565.94	6,009.09	49,171.71	55,180.80
	Cotton	17.10	2,106.29	1,193.58	6,138.90	273.60	2,462.40	369.36	1,149.12	896.04	579.60	1,210.68	13,975.31	15,185.99
	Sorghum	11.60	1,428.83	808.92	4,160.53	102.08	417.60	1,380.40	272.52	607.84	393.18	820.51	8,712.98	9,533.49
	Beans	5.10	628.19	363.97	1,870.85	73.44	183.60	473.38	726.83	267.24	172.96	369.07	4,446.39	4,815.46
	Total	80.02	9,853.97	8,329.34	42,446.68	818.72	4,726.80	5,150.37	6,406.26	4,192.00	2,711.58	8,409.35	76,306.49	84,715.74
5	Sesame	46.31	5,702.99	5,994.31	30,434.53	370.40	1,666.80	3,055.80	4,444.80	-	1,569.53	6,040.62	47,244.85	53,285.47
	Cotton	17.30	2,130.92	1,230.61	6,326.03	276.80	2,491.20	404.82	1,259.44	-	586.46	1,247.91	13,475.67	14,723.58
	Sorghum	11.40	1,404.19	804.46	4,136.30	100.32	410.40	1,396.50	232.87	-	386.45	815.86	8,067.03	8,882.89
	Beans	5.00	615.87	363.83	1,869.17	72.00	180.00	518.70	851.20	-	169.50	368.83	4,276.44	4,645.27
	Total	80.02	9,853.97	8,393.21	42,766.03	819.52	4,748.40	5,375.82	6,788.31	-	2,711.94	8,473.22	73,064.00	81,537.22
6	Sesame	46.41	5,715.30	6,025.81	30,593.07	371.20	1,670.43	3,184.90	4,632.58	-	1,573.13	6,072.22	47,740.58	53,812.80
	Cotton	17.40	2,143.24	1,266.72	6,507.60	278.40	2,505.60	446.31	1,388.52	-	589.93	1,284.12	13,859.60	15,143.72
	Sorghum	11.10	1,367.24	792.54	4,073.70	97.68	399.60	1,398.60	220.33	-	376.33	803.64	7,933.48	8,737.12
	Beans	5.10	628.19	377.74	1,939.70	73.44	183.60	580.79	953.09	-	172.91	332.84	4,531.72	4,914.56
	Total	80.02	9,853.97	8,462.81	43,114.07	820.72	4,759.20	5,610.59	7,194.51	-	2,712.30	8,542.83	74,065.36	82,608.19
7	Sesame	46.51	5,727.62	6,057.40	30,752.00	372.00	1,674.00	3,314.52	4,821.12	-	1,586.38	6,103.91	48,247.64	54,351.55
	Cotton	17.50	2,155.56	1,297.33	6,661.67	280.00	2,520.00	480.37	1,494.50	-	597.02	1,314.83	14,189.12	15,503.95
	Sorghum	10.90	1,342.60	787.34	4,045.72	97.92	392.40	1,411.55	224.14	-	371.86	798.24	7,884.19	8,682.43
	Beans	5.20	640.51	391.91	2,011.53	74.88	187.20	644.90	1,058.40	-	177.40	397.11	4,794.72	5,191.83
	Total	80.12	9,866.29	8,533.98	43,470.92	822.80	4,773.60	5,851.35	7,598.07	-	2,732.66	8,614.10	75,115.68	83,729.78
8	Sesame	46.61	5,739.94	6,089.07	30,911.33	372.80	1,677.60	3,444.67	5,010.43	-	1,588.02	6,135.68	48,744.79	54,880.47
	Cotton	17.60	2,167.87	1,334.08	6,846.40	281.60	2,534.40	522.72	1,626.24	-	599.76	1,351.68	14,578.99	15,930.67
	Sorghum	10.70	1,317.97	781.81	4,016.07	94.16	385.20	1,423.10	224.29	-	364.63	792.51	7,825.42	8,617.93
	Beans	5.30	652.83	406.86	2,087.32	76.32	190.80	715.18	1,173.63	-	180.61	412.16	5,076.69	5,488.85
	Total	80.22	9,878.61	8,611.82	43,861.12	824.88	4,788.00	6,105.67	8,034.59	-	2,733.02	8,692.04	76,225.89	84,917.92
9	Sesame	46.51	5,727.62	6,094.60	30,938.00	372.00	1,674.00	3,560.04	5,178.24	-	1,584.82	6,141.11	49,034.72	55,175.83
	Cotton	17.80	2,192.51	1,372.97	7,042.87	284.80	2,563.20	560.70	1,744.40	-	606.66	1,390.77	14,995.14	16,385.91
	Sorghum	10.50	1,293.33	775.95	3,984.75	92.40	378.00	1,433.25	227.87	-	357.86	786.45	7,767.46	8,553.91
	Beans	5.40	665.14	421.56	2,161.80	77.76	194.40	783.43	1,285.63	-	184.04	426.96	5,352.20	5,779.16
	Total	80.22	9,878.61	8,665.08	44,127.42	826.96	4,809.60	6,337.42	8,436.14	-	2,733.38	8,745.30	77,149.52	85,894.82
10	Sesame	45.51	5,653.72	6,034.32	30,630.60	367.20	1,652.40	3,635.28	5,287.68	-	1,564.37	6,079.83	48,789.25	54,870.08
	Cotton	18.20	2,241.78	1,434.16	7,352.80	291.20	2,620.80	614.25	1,911.00	-	620.30	1,452.36	15,652.13	17,104.49
	Sorghum	10.30	1,268.70	769.75	3,951.77	90.64	370.80	1,442.00	233.64	-	351.05	780.05	7,708.60	8,488.65
	Beans	6.20	714.41	460.91	2,362.53	83.52	208.80	904.80	1,484.80	-	197.68	467.11	5,956.54	6,422.65
	Total	80.22	9,878.61	8,699.14	44,297.70	832.56	4,852.80	6,596.33	8,917.12	-	2,733.38	8,779.36	78,108.50	86,887.85

[a]Tractor cost estimate (as in Tendaho case): fuel, 57 per cent; wages, 10 per cent; parts/maintenance, 33 per cent (non-cash tractor costs consist of subsistence food for drivers).

[b]Transport costs: no bridge--sesame, $2.00/quintal; cotton, $2.20/q.; sorghum, $1.80/q.; beans, $2.00/q.; with bridge--$1.28, $1.40, $1.08, $1.28 respectively. Bridge assumed to be in operation in t=3.

[c]U.S. dollars.

[d]Small errors due to rounding.

TABLE C.5 Setit-Humera: Annual crop areas, and summary of total production, budget model (t=0,...,10)

Crop	Item	Yield level	Unit	Crop areas and summary of total crop production at indicated year: 0	1	2	3	4	5	6	7	8	9	10
					Strategy I Years 1-10									
Sesame	Area	H,L	hectares	240	413	446	455	462	463	464	465	466	465	459
	Total production	H	quintals	}1,440	2,601.90	2,943.60	3,139.50	3,326.40	3,472.50	3,619.20	3,766.50	3,914.48	4,045.50	4,131.00
		L	quintals		2,560.60	2,809.80	2,957.50	3,095.40	3,148.40	3,248.00	3,348.00	3,448.40	3,487.50	3,539.30
Cotton	Area	H,L	hectares	200	137	154	163	171	173	174	175	176	178	182
	Total production	H	quintals	} 600	465.80	600.60	700.90	820.80	899.60	991.80	1,067.50	1,161.60	1,246.00	1,365.00
		L	quintals		438.40	523.60	554.20	666.90	709.30	748.20	805.00	844.80	890.00	964.60
Grain sorghum	Area	H,L	hectares	360	150	120	118	116	114	111	109	107	105	103
	Total production	H	quintals	}5,202.63	2,275.00	1,868.36	1,894.67	1,919.02	1,941.62	1,944.18	1,962.23	1,978.24	1,992.40	2,004.69
		L	quintals		2,230.14	1,808.74	1,812.67	1,803.72	1,794.33	1,778.78	1,778.16	1,765.68	1,752.55	1,749.02
Beans	Area	H,L	hectares	-	100	80	64	51	50	51	52	53	54	58
	Total production	H	quintals	} -	800.00	744.00	678.40	606.90	665.00	744.60	826.80	916.90	1,004.40	1,160.00
		L	quintals		800.00	688.00	595.20	510.00	530.00	576.30	624.00	677.80	718.20	812.00
All crops	Area: Subsistence	H	hectares	87.70	107.53	107.58	105.72	103.82	101.68	99.67	97.78	96.07	94.18	92.18
	Cash crops	H	hectares	712.30	692.47	692.42	694.28	696.18	698.32	700.33	703.22	705.93	707.82	709.82
	Total	H	hectares	800.00	800.00	800.00	800.00	800.00	800.00	800.00	801.00	802.00	802.00	802.00
	Subsistence	L	hectares	-	109.34	102.25	109.13	108.91	107.96	106.50	105.25	104.55	103.58	101.86
	Cash crops	L	hectares	-	690.66	697.75	690.87	691.09	692.04	693.50	695.75	697.45	698.42	700.14
	Total	L	hectares	-	800.00	800.00	800.00	800.00	800.00	800.00	801.00	802.00	802.00	802.00
					Strategy II Years 1-10									
Sesame	Area	H,L	hectares	-	413	468	489	496	498	499	500	498	488	473
	Total production	H	quintals	-	2,601.90	3,088.80	3,374.10	3,571.20	3,735.00	3,892.20	4,050.00	4,183.40	4,245.60	4,251.00
		L	quintals	-	2,560.60	2,948.40	3,178.50	3,323.20	3,386.40	3,493.00	3,600.00	3,685.20	3,660.00	3,642.00
Cotton	Area	H,L	hectares	-	137	132	151	158	160	161	162	164	170	180
	Total production	H	quintals	-	465.80	514.80	649.30	758.40	832.00	917.70	988.20	1,082.40	1,190.00	1,350.00
		L	quintals	-	438.40	448.80	513.40	616.20	656.00	692.30	745.20	787.20	850.00	954.00
Grain sorghum	Area	H,L	hectares	-	150	120	96	93	92	90	88	87	85	82
	Total production	H	quintals	-	2,287.00	1,879.80	1,541.82	1,538.29	1,566.92	1,576.48	1,584.07	1,608.80	1,613.38	1,596.10
		L	quintals	-	2,242.29	1,819.37	1,475.12	1,445.86	1,448.07	1,442.40	1,435.49	1,436.00	1,419.28	1,392.70
Beans	Area	H,L	hectares	-	100	80	64	53	50	51	52	53	59	67
	Total production	H	quintals	-	800.00	744.00	678.40	630.70	665.00	744.60	826.80	916.90	1,097.40	1,340.00
		L	quintals	-	800.00	688.00	529.20	530.00	530.00	576.30	624.00	667.80	784.70	938.00
All crops	Area: Subsistence	H	hectares	-	81.30	85.24	85.21	83.75	82.05	80.59	79.15	77.53	75.42	73.16
	Cash crops	H	hectares	-	718.70	714.76	714.79	716.25	717.95	720.41	722.85	724.47	726.58	728.84
	Total	H	hectares	-	800.00	800.00	800.00	800.00	800.00	801.00	802.00	802.00	802.00	802.00
	Subsistence	L	hectares	-	82.72	87.36	87.92	87.80	87.10	86.07	85.14	84.31	82.78	80.56
	Cash crops	L	hectares	-	717.28	712.64	712.08	712.20	712.90	715.93	716.86	717.69	719.22	721.44
	Total	L	hectares	-	800.00	800.00	800.00	800.00	800.00	801.00	802.00	802.00	802.00	802.00

TABLE C.6 Setit-Humera: Summary of annual gross incomes, budcet model (t=0,...,10)

Income	Crop	Annual gross incomes of indicated year										
		0	1	2	3	4	5	6	7	8	9	10
		dollars[a]										
			Strategy I Years 1-10: High-level yields									
Non-cash	Food & cash[b]	5,413.12	7,824.56	8,080.86	8,189.32	8,290.85	8,353.82	8,422.44	8,492.71	8,569.55	8,622.06	8,655.64
Cash	Cash	63,783.63	74,939.73	82,432.96	88,276.95	94,370.41	99,888.49	105,857.43	111,524.25	117,722.53	123,330.24	129,547.71
Total		69,196.74[c]	82,764.29	90,513.82	96,466.27	102,661.26	108,242.31	114,279.87	120,016.95	126,292.08	131,952.30	138,203.35
			Strategy I Years 1-10: Low-level yields									
Non-cash	Food & cash		7,802.73	8,022.59	8,095.40	8,181.92	8,211.01	8,249.64	8,300.99	8,344.46	8,363.82	8,368.99
Cash	Cash		73,227.23	77,043.96	79,840.46	84,489.53	86,734.31	90,044.36	93,882.89	97,217.57	99,536.40	103,222.62
Total			81,029.97	85,066.55	87,935.87	92,670.82	94,945.32	98,294.00	102,183.88	105,562.02	107,900.21	111,591.61
			Strategy II Years 1-10: High-level yields									
Non-cash	Food & cash		5,916.17	6,403.44	6,600.85	6,684.60	6,741.66	6,810.52	6,874.71	6,916.36	6,904.59	6,869.75
Cash	Cash		76,907.15	84,943.04	91,594.82	97,735.10	103,286.48	109,338.14	115,041.97	121,023.97	126,738.05	133,247.93
Total			82,823.31	91,346.48	98,195.67	104,419.70	110,028.14	116,148.66	121,916.68	127,940.33	133,642.64	140,117.68
			Strategy II Years 1-10: Low-level yields									
Non-cash	Food & cash		5,901.73	6,357.77	6,522.27	6,595.33	6,624.69	6,667.37	6,715.70	6,729.33	6,685.04	6,619.15
Cash	Cash		75,187.03	79,683.06	83,213.02	87,858.09	90,107.92	93,537.75	97,392.45	100,568.57	102,716.40	106,364.65
Total			81,088.76	86,040.83	89,735.29	94,453.42	96,732.61	100,205.12	104,108.15	107,297.90	109,401.45	112,983.80

[a] U.S. dollars.
[b] Sesame grain for both food and cash.
[c] Small errors due to rounding.

TABLE C.7 Setit-Humera: Annual labor use in field operations, budget model (t=0,...,10)

Field operation	Working day	Annual field labor requirements at indicated year										
		0	1	2	3	4	5	6	7	8	9	10
	hours	man-days										
		Strategy I Years 1-10: High-level yields										
Manual labor												
Planting	8	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,005	4,010	4,010	4,010
Cultivating	8	1,120	10,834	11,068	10,942	10,834	10,834	10,870	10,908	10,946	10,946	10,910
Weeding & thinning	8	16,616	19,430	19,832	19,859	19,886	19,912	19,953	20,006	20,060	20,087	20,113
Spraying	8	-	663	646	637	629	627	626	626	626	624	620
Harvesting	8	18,600	23,818	25,269	25,943	26,608	26,934	27,297	27,622	28,005	28,261	28,417
Threshing & winnowing[a]	8	5,520	5,819	5,949	6,162	6,357	6,625	6,902	7,193	7,491	7,763	8,041
Clearing	8	16,000	14,000	14,400	14,720	14,980	15,000	14,980	14,980	14,980	14,960	14,880
Total		61,856	78,564	81,164	82,263	83,294	83,932	84,628	85,340	86,118	86,651	86,991
Machine operations												
(1 man) Plowing (disc)	8-10	267	267	267	267	267	267	267	267	267	267	267
(1 man) Discing	8-10	133	133	133	133	133	133	133	134	134	134	134
		400	400	400	400	400	400	400	401	401	401	401
Total field labor		62,256	79,964	81,564	82,663	83,694	84,332	85,028	85,741	86,519	87,052	87,392
		Strategy I Years 1-10: Low-level yields										
Total manual labor	8		78,342	80,572	81,311	82,182	82,484	82,875	83,395	83,835	84,031	84,084
Total machine labor	8-10		400	400	400	400	400	400	401	401	401	401
Total field labor			78,742	80,972	81,711	82,582	82,884	83,275	83,796	84,236	84,432	84,485
		Strategy II Years 1-10: High-level yields										
Manual labor												
Planting	8		2,565	2,740	2,765	2,745	2,740	2,750	2,760	2,755	2,735	2,700
Cultivating	8		10,260	10,960	11,060	10,980	10,960	11,000	11,040	11,020	10,940	10,800
Weeding & thinning	8		8,710	9,112	9,434	9,474	9,487	9,527	9,568	9,581	9,608	9,648
Spraying	8		663	668	649	642	640	640	640	638	632	622
Harvesting	8		21,493	24,089	25,411	26,028	26,347	26,686	26,974	27,201	27,133	27,020
Threshing & winnowing	8		4,269	4,863	5,177	5,392	5,645	5,934	6,227	6,495	6,538	7,016
Clearing	8		11,260	11,760	11,700	11,780	11,800	11,780	11,760	11,700	11,460	11,110
Total			59,220	64,192	66,196	67,041	67,619	68,317	68,969	69,390	69,266	68,906
Machine operations												
(1 man) Plowing	8-10		267	267	267	267	267	267	267	267	267	267
(2 men) Planting	8		57	50	49	50	50	50	50	50	51	52
(2 men) Cultivating	8		144	126	124	125	126	126	125	126	128	131
(2 men) Combining	8-10		9	8	6	6	6	6	6	6	6	6
(2 men) Clearing	8		35	33	38	40	40	40	40	41	42	45
Total			512	484	484	488	489	489	488	490	494	501
Total field labor			59,732	64,676	66,680	67,528	68,108	68,806	69,457	69,879	69,760	69,407
		Strategy II Years 1-10: Low-level yields										
Total manual labor	8		59,073	63,729	65,399	66,136	66,432	66,865	67,356	67,493	67,039	66,364
Total machine labor	8-10		512	484	484	488	489	489	488	490	494	501
Total field labor			59,585	64,213	65,883	66,624	66,921	67,354	67,844	67,983	67,533	66,865

[a]Difference between manual labor requirements between high- and low-level yields is due to harvesting, threshing, and winnowing requirements.

TABLE C.8 Setit-Humera: Inputs of seed, spray, and transportation requirements, budget model (t=0,...,10)

Crop	Seed price		Seed rate		Spray cost	Transportation	
Year:	0	1-10	0	1-10	1-10	0-2	3-10
	-----$/q.[a]-----		-----q/ha.-----		---$/ha.[a]---	------$/q.[a]-------	
Sesame	18.14	16.00	.03	.05	3.60[b]	2.00	1.28
Cotton	14.16	10.00	.08	.16	14.40[c]	2.20	1.40
Sorghum	8.06	8.00	.05	.11	3.60	1.80	1.08
Beans	-	8.00	-	.18	3.60	2.00	1.28

[a]U.S. dollars.

[b]One application of a general purpose insecticide; cost of equipment included in depreciation charges of this model.

[c]Three aerial applications of appropriate cotton insecticides: equipment charge, $1.20/ha. per application; insecticide cost, $3.60 per application.

Sources: Seed rates as observed for initiating year, also see Report of the Survey Mission . . ., p. 39.
Seed prices as observed for initiating, for subsequent years see Miller, *et al*., *Systems Analysis Methods . . .*, p. 105.
Spray costs and information, *ibid*., p. 104. Transportation and handling costs, *ibid*., p. 101.

TABLE C.9 Setit-Humera: Summary of annual total costs for inputs (excluding financial charges), budget model (t=0,...,10)

Year	Tractor		Labor		Seeds	Sprays	Sacks	Transport	Clearing	Depreciation	Total inputs		
	Non-cash	Cash	Non-cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Non-cash	Cash	Total
	dollars[a]												
0	80.02	9,853.97	6,185.60	31,728.00	480.48	-	5,317.20	11,551.60	4,192.00	2,649.80	6,265.62	65,773.05	72,038.66[b]
Strategy I Years 1-10: High-level yields													
1	80.02	9,853.97	7,856.39	40,081.93	825.60	4,359.60	4,750.78	9,013.60	4,192.00	2,708.70	7,936.40	75,786.19	83,722.59
2	80.02	9,853.97	8,116.35	40,381.73	824.00	4,543.20	4,784.96	9,054.29	4,192.00	2,710.68	8,196.36	77,344.84	85,541.20
3	80.02	9,853.97	8,226.35	41,931.77	820.80	4,640.40	4,970.22	6,087.05	4,192.00	2,711.04	8,306.37	75,207.24	83,513.61
4	80.02	9,853.47	8,329.34	42,446.68	818.72	4,726.80	5,150.37	6,406.26	4,192.00	2,711.58	8,409.35	76,306.39	84,715.74
5	80.02	9,853.97	8,393.21	42,766.03	819.52	4,748.40	5,375.82	6,788.31	-	2,711.94	8,473.22	73,064.00	81,537.22
6	80.02	9,853.97	8,462.81	43,114.07	820.72	4,759.20	5,610.59	7,194.51	-	2,712.30	8,542.83	74,065.36	82,608.19
7	80.12	9,866.29	8,533.98	43,470.92	822.80	4,773.60	5,851.35	7,598.07	-	2,732.66	8,614.10	75,115.68	83,729.78
8	80.22	9,878.61	8,611.82	43,861.12	824.88	4,788.00	6,105.67	8,034.59	-	2,733.02	8,692.04	76,225.89	84,917.92
9	80.22	9,878.61	8,665.08	44,127.42	826.96	4,809.60	6,337.42	8,436.14	-	2,733.38	8,745.30	77,149.52	85,894 82
10	80.22	9,878.61	8,699.14	44,297.70	832.56	4,852.80	6,596.33	8,917.12	-	2,733.38	8,779.36	78,108.50	86,887.85
Strategy I Years 1-10: Low-level yields													
1	80.02	9,853.97	7,834.25	39,971.23	825.60	4,359.60	4,670.61	8,798.09	4,192.00	2,708.70	7,914.26	75,499.62	83,293.88
2	80.02	9,853.97	8,057.24	41,086.20	824.00	4,543.20	4,546.88	8,419.64	4,192.00	2,710.68	8,137.26	76,176.21	84,313.47
3	80.02	9,853.97	8,131.10	41,455.50	820.80	4,640.40	4,621.33	5,474.61	4,192.00	2,711.04	8,211.12	73,769.28	81,980.40
4	80.02	9,853.97	8,218.21	41,891.07	818.72	4,726.80	4,721.06	5,671.01	4,192.00	2,711.58	8,298.23	74,585.67	81,883.90
5	80.02	9,853.97	8,248.36	42,041.80	819.52	4,748.40	4,795.94	5,807.04	-	2,711.94	8,328.38	70,777.89	79,106.26
6	80.02	9,853.97	8,287.54	42,237.70	820.72	4,759.20	4,926.49	6,022.84	-	2,712.30	8,367.56	71,332.33	79,699.88
7	80.12	9,866.29	8,339.52	42,498.60	822.80	4,773.60	5,077.05	6,279.28	-	2,732.66	8,419.64	72,029.38	80.449.02
8	80.22	9,878.61	8,383.51	42,719.57	824.88	4,788.00	5,208.94	6,496.40	-	2,733.02	8,463.73	72,628.33	81,092.06
9	80.22	9,878.61	8,403.15	42,817.73	826.96	4,809.60	5,293.90	6,655.75	-	2,733.38	8,483.36	72,994.66	81,478.03
10	80.22	9,878.61	8,408.40	42,843.98	832.56	4,852.80	5,439.36	6,935.19	-	2,733.38	8,488.61	73,494.62	81,983.23
Strategy II Years 1-10: High-level yields													
1	78.74	11,619.07	5,921.99	30,122.93	825.60	4,359.60	4,750.78	9,745.28	4,192.00	4,203.58	6,000.73	69,818.85	75,819.58
2	75.79	11,017.29	6,419.17	32,643.87	806.40	4,305.60	4,874.12	9,799.06	4,192.00	4,207.18	6,498.96	71,845.52	78,340.49
3	75.61	10,954.97	6,619.58	33,650.90	809.44	4,510.80	4,899.34	6,288.47	4,192.00	4,228.80	6,659.19	69,534.72	76,229.92
4	76.03	11,031.45	6,704.11	34,069.55	807.76	4,586.40	5,082.58	6,609.94	4,192.00	4,229.16	6,780.14	70,608.84	77,388.98
5	76.14	11,050.87	6,761.89	34,357.43	807.36	4,608.00	5,306.90	6,984.74	-	4,229.52	6,838.03	67,344.82	74,182.85
6	76.14	11,043.26	6,831.73	34,708.63	809.44	4,622.40	5,552.89	7,402.78	-	4,229.88	6,907.86	68,369.29	75,277.15
7	76.13	11,035.65	6,896.84	35,036.20	811.52	4,636.80	5,793.19	7,802.55	-	4,230.24	6,972.97	69,346.16	76,319.13
8	76.24	11,055.07	6,938.98	35,245.92	813.68	4,658.40	6,040.58	8,237.68	-	4,230.42	7,015.22	70,281.74	77,296.97
9	76.64	11,130.36	6,926.63	35,180.17	822.16	4,723.20	6,287.85	8,706.80	-	4,230.24	7,003.28	71,080.77	78,084.05
10	77.35	11,261.51	6,890.60	34,993.00	835.04	4,831.20	6,546.86	9,245.03	-	4,230.06	6,967.95	71,942.70	78,910.65
Strategy II Years 1-10: Low-level yields													
1	78.74	11,619.07	5,907.35	30,049.73	825.60	4,359.60	4,670.61	9,526.94	4,192.00	4,203.58	5,986.09	69,447.13	75,433.22
2	75.79	11,017.29	6,372.85	32,412.27	806.40	4,305.60	4,635.19	9,170.57	4,192.00	4,207.00	6,448.64	70,746.32	77,149.96
3	75.61	10,954.97	6,539.88	33,252.40	809.44	4,510.80	4,554.13	5,686.85	4,192.00	4,208.44	6,615.49	68,169.02	74,784.51
4	76.03	11,031.45	6,613.57	33,616.87	807.76	4,586.40	4,656.71	5,884.61	4,192.00	4,228.80	6,689.60	69,004.60	75,614.20
5	76.14	11,050.87	6,643.24	33,764.20	807.36	4,608.00	4,731.91	6,017.07	-	4,228.98	6,719.38	65,208.40	71,927.77
6	76.14	11,043.26	6,686.54	33,982.68	809.44	4,622.40	4,874.39	6,247.95	-	4,229.16	6,762.67	65,809.29	72,571.96
7	76.13	11,035.65	6,735.56	34,229.80	811.52	4,636.80	5,024.94	6,501.78	-	4,229.52	6,811.69	66,470.01	73,281.70
8	76.24	11,055.07	6,749.27	34,297.37	813.68	4,658.40	5,153.40	6,723.21	-	4,229.52	6,825.51	66,930.65	73,756.17
9	76.64	11,130.36	6,703.95	34,066.75	822.16	4,723.20	5,238.77	2,920.34	-	4,229.34	6,780.59	67,130.91	73,911.51
10	77.35	11,261.51	6,636.41	33,722.07	835.04	4,831.20	5,370.49	7,224.25	-	4,228.98	6,713.76	67,474.53	74,188.29

[a] U.S. dollars.

[b] Small errors due to rounding.

Financial Costs

Three financial charges have been included in the budget. A crop loan is taken out annually to meet the costs of inputs until cash income is realized from harvested crops. The interest rate is 8 per cent per annum charged on a monthly basis. Medium-term loans are used by the farmer to purchase tools and equipment. The interest charge on these loans is 7 per cent per annum; the loan being repaid in seven years. Overdraft accommodation (short-term loan) has been included to enable negative cash margins on any year's accounts to be carried forward into the following year as a cost being charged 7 per cent per annum interest.

These loan and interest charges are shown in Table C.10. The final amount for financial costs is determined by subtracting the cash fund accumulated through depreciation charges.

Budget Summary

The complete budget model is summarized in Table C.11. In this table only aggregate data are recorded.

Additional Requirements

The budget model has been prepared on the assumption that the farmer is able to obtain the average seasonal price for his produce. There are some price fluctuations over the season[1] and, therefore, this assumption may or may not be valid.

Two approaches to additional requirements are presented in Table C.12. The first set of data is presented under an assumption that farmers have their produce hauled directly to Asmera, in which case the currently ruling price will be realized. The second set of data is presented under an assumption that storage and market assistance facilities are established in the area, in which case the farmer is more likely to realize the seasonal average price. (Benefit-cost analyses of generated budget data employs only the first set of additional costs.)

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[1] *Report of the Survey Mission . . .*, pp. 29-30.

TABLE C.10 Setit-Humera: Annual financial charges and net financial costs, budget model (t=0,...,10)

Item	0	1	2	3	4	5	6	7	8	9	10
	Annual financial charges and costs at indicated year										
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Crop loan	1,677.80	2,362.90	2,436.39	2,407.39	2,425.33	2,437.61	2,451.10	2,466.41	2,480.39	2,490.36	2,494.16
Overdraft	-	5,884.16	11,744.23	11,744.95	3,174.71	-	-	-	-	-	-
Medium term loan	4,081.80	4,191.09	4,194.76	4,195.43	4,196.43	4,197.10	4,197.77	4,235.55	4,236.22	4,236.89	4,236.89
Total	5,759.60	12,438.15	18,375.38	18,347.77	9,796.47	6,634.71	6,648.87	6,701.96	6,716.61	6,727.25	6,731.05
Less depreciation fund	2,649.80	2,708.70	2,710.68	2,711.04	2,711.58	2,711.94	2,712.30	2,732.66	2,733.02	2,733.38	2,733.38
Net financial costs	3,109.80	9,729.45	15,664.71[b]	15,636.73	7,084.90	3,922.78	3,936.57	3,969.30	3,983.59	3,993.96	3,997.67
		Strategy I Years 1-10: Low-level yields									
Crop loan		2,359.42	2,424.13	2,395.08	2,409.70	2,415.68	2,425.99	2,438.11	2,450.24	2,454.08	2,455.18
Overdraft		5,884.16	13,137.68	17,739.36	17,063.65	15,255.65	641.42	-	-	-	-
Medium term loan		4,190.76	4,194.10	4,194.76	4,195.43	4,195.77	4,196.10	4,196.77	4,197.10	4,197.44	4,197.44
Total		12,434.34	19,755.91	24,329.20	23,668.78	18,867.10	7,263.51	6,634.88	6,647.34	6,651.52	6,652.62
Less depreciation fund		2,708.52	2,710.32	2,710.68	2,711.04	2,711.22	2,711.40	2,711.76	2,711.94	2,712.12	2,712.12
Net financial costs		9,725.82	17,046.59	21,618.52	20,957.74	16,155.88	4,552.12	3,923.12	3,935.40	3,939.40	3,940.49
		Strategy II Years 1-10: High-level yields									
Crop loan		1,992.15	1,971.70	1,972.11	1,992.68	2,006.32	2,021.07	2,035.86	2,045.00	2,046.73	2,044.23
Overdraft		5,884.16	4,225.78	-	-	-	-	-	-	-	-
Medium term loan		6,964.89	6,971.57	7,011.69	7,012.35	7,013.02	7,013.69	7,014.36	7,014.69	7,014.36	7,014.02
Total		14,841.20	13,169.05	8,983.80	9,005.03	9,019.34	9,034.76	9,050.22	9,059.69	9,061.09	9,058.25
Less depreciation fund		4,203.58	4,207.18	4,228.80	4,229.16	4,229.52	4,229.88	4,230.24	4,230.42	4,230.24	4,230.06
Net financial costs		10,637.62	8,961.87	4,754.99	4,775.88	4,789.82	4,804.68	4,819.98	4,829.27	4,830.85	4,828.19
		Strategy II Years 1-10: Low-level yields									
Crop loan		1,988.67	1,959.87	1,958.86	1,977.27	1,982.71	1,994.05	2,005.41	2,011.29	2,007.10	2,002.61
Overdraft		5,884.16	5,664.84	1,981.86	-	-	-	-	-	-	-
Medium term loan		6,964.89	6,971.23	6,973.91	7,011.69	7,012.02	7,012.35	7,013.02	7,013.02	7,012.69	7,012.02
Total		14,833.72	14,595.94	10,914.63	8,988.96	8,994.73	9,006.40	9,018.43	9,024.31	9,019.79	9,014.63
Less depreciation fund		4,203.58	4,207.00	4,208.44	4,228.80	4,228.98	4,229.16	4,229.52	4,229.52	4,229.34	4,228.98
Net financial costs		10,634.14	10,388.94	6,706.18	4,760.16	4,765.75	4,777.24	4,788.91	4,794.79	4,790.45	4,785.65

[a] U.S. dollars.

[b] Small errors due to rounding.

TABLE C.11 Setit-Humera: Summary of budget model accounts (t=0,...,10)

Item	Annual account summary at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
	Strategy I High-level yields										
Gross income	69,196.74	82,764.29	90,513.82	96,466.27	102,661.26	108,242.31	114,279.87	120,016.95	126,292.08	131,952.30	138,203.35
less total costs[b]	72,438.66	84,122.59	85,941.20	83,913.61	85,115.74	81,937.22	83,008.19	84,129.78	85,317.92	86,294.82	87,287.85
Net returns	-3,241.92	-1,358.30	4,572.62	12,552.66	17,545.52	26,305.09	31,271.68	35,887.17	40,974.16	45,657.48	50,915.50
less net financial costs	3,109.80	9,729.45	15,664.71	15,636.73	7,084.90	3,922.78	3,936.57	3,969.30	3,983.59	3,993.96	3,997.67
Net income	-6,351.72	-11,087.75	-11,092.09	-3,084.07	10,460.62	22,382.31	27,335.11	31,917.87	36,990.57	41,663.52	46,917.83
	Strategy I Years 1-10: Low-level yields										
Gross income		81,029.97	85,066.55	87,935.87	92,670.82	94,945.32	98,294.00	102,183.88	105,562.02	107,900.21	111,591.61
less total costs[b]		83,693.88	84,713.47	82,380.40	83,283.90	79,506.26	80,099.88	80,849.02	81,492.06	81,878.03	82,383.23
Net returns		-2,663.91	353.08	5,555.47	9,386.92	15,439.06	18,194.11	21,334.86	24,069.96	26,022.18	29,208.38
less net financial costs		9,725.82	17,046.59	21,618.52	20,957.74	16,155.88	4,552.12	3,923.12	3,935.40	3,939.40	3,940.49
Net income		-12,389.73	-16,693.51	-16,063.05	-11,570.82	-716.82	13,642.00	17,411.74	20,134.57	22,082.79	25,267.89
	Strategy II Years 1-10: High-level yields										
Gross income		82,823.31	91,346.48	98,195.67	104,419.70	110,028.14	116,148.66	121,916.68	127,940.33	133,642.64	140,117.68
less total costs[b]		76,219.58	78,740.49	76,629.92	77,788.98	74,582.85	75,677.15	76,719.13	77,696.97	78,484.05	79,310.65
Net returns		6,603.73	12,605.99	21,567.75	26,630.72	35,445.29	40,471.51	45,197.55	50,243.36	55,158.59	60,807.03
less financial costs		10,637.62	8,961.87	4,754.99	4,775.88	4,789.82	4,804.88	4,819.98	4,829.27	4,830.85	4,828.19
Net income		-4,033.89	3,644.12	16,810.76	21,854.84	30,655.48	35,666.63	40,377.57	45,414.09	50,327.73	55,978.84
	Strategy II Years 1-10: Low-level yields										
Gross income		81,088.76	86,040.83	89,735.29	94,453.42	96,732.61	100,205.12	104,108.15	107,297.90	109,401.45	112,983.80
less total costs[b]		75,833.22	77,594.96	75,184.51	76,094.20	72,327.77	72,971.96	73,681.70	74,156.17	74,311.51	74,588.29
Net returns		5,255.54	8,445.87	14,550.78	18,359.22	24,404.84	27,233.16	30,426.45	33,141.73	35,089.94	38,395.51
less financial costs		10,634.14	10,388.94	6,706.18	4,760.16	4,765.75	4,777.24	4,788.91	4,794.79	4,790.45	4,785.65
Net income		-5,378.60	-1,943.08	7,844.59	13,599.06	19,639.09	22,455.93	25,637.54	28,346.94	30,299.49	33,609.85

[a]U.S. dollars.

[b]Excluding financial charges (as in Table C.9) but including an additional $400 family cash allowance not included in annual input accounts.

TABLE C.12 Setit-Humera: Estimated annual costs for additional personnel, equipment, and supporting costs for strategies I and II (100 farmers), without and with marketing facilities during budget period (t=0,...,10)[a]

Item	Annual additional costs at indicated year: 1	2	3	4	5	6	7	8	9	10
	dollars[b]									
Strategies I and II (without marketing facilities)										
Personnel										
Salaries[c]	9,000	9,300	9,600	9,900	10,200	10,200	10,500	10,500	10,800	10,800
Per diem[d]	800	800	800	800	800	800	800	800	800	800
Total	9,800	10,100	10,400	10,700	11,000	11,000	11,300	11,300	11,600	11,600
Vehicle[e]										
Cost (7% p.a.; 3 yr.)[f]	(1)[g] 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387	(1) 1,387
Maintenance	400	400	400	400	400	400	400	400	400	400
Fuel	800	800	800	800	800	800	800	800	800	800
Total	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587	2,587
Supplies[h]	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Total costs	13,587	13,887	14,187	14,497	14,777	14,787	15,087	15,087	15,387	15,387
Strategies I and II (with marketing facilities										
Personnel										
Salaries[i]	9,000	9,300	13,440	13,860	14,280	14,280	14,700	14,700	15,120	15,120
Per diem[d]	800	800	800	800	800	800	800	800	800	800
Wages[j]	562	562	562	562	562	562	562	562	562	562
Subsistence[k]	94	94	94	94	94	94	94	94	94	94
Total	10,546	10,756	14,896	15,316	15,736	15,736	16,156	16,156	16,576	16,576
Vehicles[e] (total costs)	(2)[g] 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174	(2) 5,174
Supplies[h]	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Equipment										
Bins[l] (7% p.a.; 7 yr.)[f]	-	-	(30)[g] 11,134	(31) 11,505	(32) 11,876	(34) 12,619	(35) 12,990	(36) 13,361	(36) 13,361	(38) 2,970
Conveyor[m] (7% p.a.; 7 yr.)[f]	-	-	(1)[g] 260	(1) 260	(1) 260	(1) 260	(1) 260	(1) 260	(1) 260	(1) -
Augurs[n] (7% p.a.; 5 yr.)[f]	-	-	(2)[g] 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64	(2) 64
Thermometer[o] (7% p.a.; 5 yr.)[f]	-	-	(1)[g] 11	(1) 11	(1) 11	(1) 11	(1) 11	(1) 11	(1) 11	(1) -
Bagger & scale[p] (7% p.a.; 5 yr.)[f]	-	-	(1)[g] 93	(1) 93	(1) 93	(1) 93	(1) 93	(1) 93	(1) 93	(1) -
Sewing machine[q] (7% p.a.; 5 yr.)[f]	-	-	(1)[g] 51	(1) 51	(1) 51	(1) 51	(1) 51	(1) 51	(1) 51	(1) -
Miscellaneous[r] (7% p.a.; 5 yr.)[f]	-	-	(1)[g] 557	(1) 557	(1) 557	(1) 557	(1) 557	(1) 557	(1) 557	(1) -
Total	-	-	12,170	12,448	12,912	13,655	14,026	14,397	14,397	3,034
Repair allowance	-	-	550	550	550	550	550	550	550	550
Total costs	16,830	17,130	33,990	34,688	35,572	36,315	37,106	37,477	37,897	26,534

[a]In benefit-cost and subsequent analyses only additional costs without marketing facilities have been considered.

[b]U.S. dollars. [c]Extension Agent, Research Officer, and Finance Officer (half-time) all paid equally.

[d]Paid to the two field officers only. [e]Land Rover(s) @ $3,640 each, acquisition price.

[f]Amortization charge; rate in parenthesis to each item. [g]Number of equipment units shown in parenthesis.

[h]Extension, demonstration, and administration materials.

[i]Extension Agent, Research Officer, Finance Officer (half-time) and Marketing Officer (employed from t=3) all paid equal rate.

[j]Six laborers employed for six months at $0.60 per day. [k]Laborers' food allowance: $0.10 per day.

[l]Bins: capacity, 65 m. tons; @ $2,000 each. [m]Conveyor: 8" dia. tube, @ $1,400 each.

[n]Augur: 6" dia., 3 h.p. engine; @ $130 each. [o]Thermometer @ $60 each.

[p]Bagger and scale @ $500 per unit. [q]Sewing machine @ $275 each.

[r]Carts, parts, electrical fittings $3,000.

Source: U.S. Agency for International Development, "Shashamanne Farm Development Project . . . ," pp. 32, A.i-ii.

The Grain Corporation has already built a small grain storage warehouse at Humera. By offering storage facilities to local farmers the Grain Corporation is able to buy grain at a price approaching the seasonal average; by holding the grain in storage the Corporation is able to benefit from seasonal rises in market prices. The cost to the farmer for receiving a price higher than that ruling at harvest time is the fact that he only receives partial payment at the time of delivering the grain, the balance being paid when the Grain Corporation has sold the stored grain.

Supervision

It is estimated that two technically competent field officers (Extension Agent and Research Officer) will be necessary to each hundred farmers. Their duties will consist of disseminating information, conducting demonstrations and giving advisory help to farmers. Thus, the two field officers are responsible for the development of about 80,000 hectares of land. The adoption of a group of model farmers increases the efficiency of field officers' endeavors.[1]

In addition to the two field officers, a financial officer will be required to handle the arrangement and servicing of loans and overdrafts. The financial officer is to be appointed to the local branch of the Development Bank of Ethiopia; his appointment will be half-time per 100 farmers.

The establishment of storage facilities (to begin operation in t=3) will entail considerably more work than the two field officers can handle. Therefore, under this assumption, a marketing officer is also to be appointed. His responsibilities will be to handle the storage and subsequent marketing of grain sold to the Grain Corporation. He may also develop an advisory service to assist farmers in marketing their produce, either directly or through the storage facilities.

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[1]Chilalo Agricultural Development Unit, "Memorandum: Criteria for Selection of Model Farmers" (Addis Abeba: Swedish International Development Agency, June, 1968). (Mimeographed.)

Equipment

The required equipment is set out in Table C.12. It has been assumed that about 33 per cent of the farmers will avail themselves of storage facilities. Equipment on inventory is sufficient for this level of demand.

Infrastructure

In the year of observation it was apparent that road conditions and the lack of a bridge were serious handicaps to the economic development of the area.[1] Both the International Bank of Reconstruction and Development and the British government have sent survey teams into the area with a view to giving financial support to road and bridge construction. It is anticipated that these infrastructural improvements will be introduced in the near future; in the budget models transportation and handling charges have been reduced in the third operational year (t=3), assuming that the bridge will have been constructed by then.

Farm (feeder) roads are also extremely inadequate but are negotiable by tractor and trailer. Since these roads are unlikely to be improved in the near future, it has been assumed in the budget model that the farmer employs an extra tractor almost completely for haulage and general transportation.

There is an obvious need for an agricultural experimental station in a region of such high economic potential. Recommended cultivation techniques and anticipated crop yields should be carefully tested under actual environmental conditions. This need has already been recognized by the Ministry of Agriculture. A small experimental farm was in the process of being established during the 1967/68 season. It is anticipated that this establishment will work in close cooperation with extension programs to be developed in the area.

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[1] Report of the Survey Mission . . ., p. 38.

APPENDIX D

TENDAHO PLANTATIONS CASE STUDY

APPENDIX D

TENDAHO PLANTATIONS CASE STUDY

Introduction

A system of large-scale commercial plantations contrasts sharply with the three previous case studies. The operation of the Tendaho Plantations Share Company represents a system of capital intensive single crop (cotton) farming under expatriate management, a form of development which is not uncommon in Equatorial Africa. This system employs imported technology and management intensively while using local labor extensively during the weeding and picking seasons.

Tendaho Plantations Share Company (share capital in 1967/68 amounted to $2,472,000) is a joint commercial venture between agencies of the Imperial Ethiopian Government, private Ethiopian shareholders, and Mitchell Cotts and Company (Ethiopia) Limited. Total accumulated investment, including long-term loans in 1967/68, amounted to $5,840,000.

The plantations are located in the Danakil Desert about 580 kilometers northeast of Addis Abeba in the lower Awash Valley. The full concession of land, a rent free agreement with the Imperial Ethiopian Government sanctioned by the Emperor, amounts to 10,000 hectares which is gradually being brought into cultivation as the operation expands. The operational unit is the "farm." "Farms" vary in size as the plantations have been expanded. In reality Tendaho Plantations consist of three plantations: Dubte, Dit Bahari and Logghia. However, since all three are managed directly from one headquarters on the site, and administered from one head office in Addis Abeba, this case study treats the entire area as a single plantation enterprise.

The plantations are accessible by road and air. Cotton is transported along the main route from Addis

Abeba to Aseb. The terrain of the country and the present condition of the road make a rugged haul for the cotton crop, either to Addis Abeba (altitude: 2,408 meters) for sale in the domestic market or to Aseb (altitude: 11 meters) for export.

Tendaho Plantations are situated 370 meters above sea level on a deep silty clay alluvium deposited by the Awash River.[1] Mean annual rainfall is 100 mm. and under natural conditions the area is a flat semi-hot desert. When irrigated the soils have proved to be extremely fertile although in the early years of operation a saline crust repressed plant growth. Continuous cultivation and irrigation have broken up this saline crust and the area is ideal for large-scale engine-powered operations. Climatic data for the area are shown in Table D.1 which also includes crop operations for the cotton-growing season, May-October/November.

Data for the Tendaho Plantations operations were obtained during the sixth and seventh years of actual operation (1967-1969). This budget model has been prepared as a synthesis of actual experience of the management and company accounts made available for inspection during the observation years. In this case the agricultural system is already established. The budget model seeks to present the case as the operation expands from the initiating year (t=0), when the area under cultivation was 1,100 hectares, to the full concession of 10,000 hectares in the final operational year of the budget model (t=10). As the operation expands, a gradual improvement is assumed to take place in the efficiency of operating the field equipment which is reflected in the estimation of cultivation machinery contained in Table D.2(a).

Two strategies have been considered. Strategy I is established on the assumption that the plantations produce and sell only raw cotton. Strategy II assumes that after the initiating year, the cotton is ginned to be sold as cotton lint and seed in the proportion of 36 per cent (by weight) lint and 62 per cent seed.

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[1] Kline, et al., op. cit., Pt. II, p. 36.

TABLE D.1 Tendaho: Climatic data and distribution of crop operations by calendar months, budget model initiating year (t=0)

Item	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Mean rainfall (mm.)	-	-	100	-	-	-	-	-	-	-	-	-
Mean temperature[a]												
Maximum (°C)	30.1	31.8	34.4	35.9	37.8	37.1	36.0	33.7	30.7	28.7	27.7	28.1
Minimum (°C)	22.9	24.5	26.6	28.9	29.8	30.0	29.0	25.4	23.2	22.6	21.9	22.6
<u>Crop (cotton) operations</u>												
Clear											—	—
Rough plowing	—											—
Planing	—	—										
Disc plowing		—	—									
Irrigation			1st		2nd	3rd	4th					
Planting			—									
Weeding (hand)					1st			2nd				
Interrow cultivation					1st	2nd	3rd					
Thinning (hand)							—					
Picking (hand)									1st	2nd	3rd	
Ginning	—											—

[a]Calculated from data recorded at Aseb (1949-1957), temperature adjusted by -.2°C for altitude change in same region from 11 to 370 meters. Huffnagel, *op. cit.*, p. 73.

TABLE D.2 Tendaho: Basic assumptions

a. Total annual cost of capital inventory in operation[a] for initiating year (t=0), strategies I and II (t=1,...,10), budget model

Item	Acquisition price	Annual capital costs at indicated year										
		0	1	2	3	4	5	6	7	8	9	10
	dollars[b]	dollars[b]										
			Strategy I: Years 1-10									
Tractors[c]	2,688-3,300[d]	32,256	59,136	118,194	118,194	137,830	161,401	183,736	230,278	256,678	296,392	329,715
Cultivation equipment and machinery[e]												
M-F Moldboard plow	760	760	760	1,520	1,250	2,280	2,280	2,280	2,280	2,280	2,280	2,280
M-F 144 Cotton cultivator	1,206	3,618	7,236	12,060	12,060	13,266	15,678	15,676	20,502	21,708	25,326	27,738
M-F Light cultivator	200	400	800	1,400	1,400	1,600	1,800	1,800	2,200	2,600	2,800	3,200
Cotton planter	612	3,672	6,732	11,628	11,628	13,464	14,638	15,912	20,196	22,644	25,704	28,764
M-F WLDH[f]	1,535	1,535	3,070	4,605	4,605	4,605	4,605	4,605	6,140	7,675	7,675	9,210
M-F No. 52 Disc harrow	1,286	3,858	6,430	11,574	11,574	12,860	14,146	15,432	21,862	25,720	25,720	28,292
Mounted disc harrow	540	540	1,080	1,620	2,160	2,160	2,160	2,160	2,700	3,240	3,240	3,890
M-F Spiked toothed harrow	216	648	108	1,728	1,728	1,944	2,160	2,376	3,024	3,456	3,888	4,320
M-F 4-furrow disc harrow	598	1,794	2,990	5,382	5,382	5,980	6,578	7,176	10,166	11,960	11,960	13,156
Dormal trailer	1,557	7,785	12,456	23,355	23,355	26,469	29,593	31,140	38,925	43,596	51,381	56,052
Rotary slasher	460	460	920	1,840	1,840	2,300	2,300	2,300	2,300	3,220	3,680	4,140
M-F tool bar & ridger	792	1,584	2,376	3,960	3,960	4,752	5,544	5,544	7,128	7,920	9,504	10,296
Eversman ditcher	1,580	1,580	3,160	4,740	4,740	4,740	4,740	4,740	6,320	7,900	7,900	9,480
Eversman land leveller	2,203	2,203	4,406	6,609	6,609	6,609	6,609	6,609	8,812	11,015	11,015	13,218
Trolley mounted pumps	1,348	1,348	2,696	4,044	4,044	5,392	5,392	5,392	6,740	8,088	9,436	10,784
34 Darman sprayer	2,172	2,172	2,172	4,344	4,344	4,344	4,344	4,344	6,516	6,516	8,688	8,688
Toolbar & cultivator	454	2,270	3,632	6,810	6,810	7,718	8,626	9,080	11,350	12,712	14,892	16,344
Wolkin grain drill	121	121	121	121	121	121	121	121	121	121	121	121
Ransom mower	586	1,172	1,758	3,516	3,516	4,102	4,688	4,688	5,860	7,032	7,618	8,790
Mobile cotton loader	1,050	3,150	4,200	8,400	8,400	9,450	10,500	10,500	13,650	14,700	17,850	18,900
Model 709 weeder	182	182	182	182	182	182	182	182	182	182	182	182
Fertilizer spreader	383	383	766	1,149	1,532	1,532	1,532	1,532	1,915	2,298	2,298	2,681
Sundry farm tools	-	248	487	900	900	1,034	1,136	1,249	1,491	1,744	1,997	2,250
Total		41,483	68,538	121,487	122,410	136,904	149,392	154,840	200,380	228,327	255,245	282,666
Irrigation equipment[g]												
Crawler	9,377	9,377	9,377	9,377	18,754	18,754	18,754	18,754	18,754	18,754	18,754	18,754
Low loader	2,314	2,314	2,314	2,314	4,628	4,628	4,628	4,628	4,628	4,628	4,628	4,628
Priestman beaver	15,517	15,567	15,567	15,567	31,035	31,035	31,035	31,035	31,035	31,035	31,035	31,035
Total		27,258	27,258	27,258	54,417	54,417	54,417	54,417	54,417	81,675	81,675	81,675
Plant and machinery[h]												
Power house	196,824[i]	196,824	196,824	196,824	196,824	196,824	196,824	196,824	196,824	196,824	196,824	196,824
Workshop	18,356[i]	18,356	18,356	18,356	36,713	36,713	36,713	36,713	73,426	73,426	73,426	73,426
Survey	841[i]	841	841	841	841	841	841	841	1,260	1,260	1,260	1,260
Water wells	4,215[i]	4,215	4,215	6,178	6,178	8,230	8,230	8,230	8,230	10,287	10,287	10,287
Furniture & fittings	36,000[i]	36,000	36,590	53,827	72,243	79,278	83,664	100,800	112,896	126,444	141,617	158,611
Total		256,236	256,826	294,383	312,799	321,886	326,272	343,408	392,636	408,241	423,414	440,408

Vehicles[j]												
Land Rovers	3,640	32,760	40,040	61,880	61,880	76,440	76,440	83,720	91,000	98,280	116,480	123,760
Trucks	10,442[k]	10,422	20,844	20,844	20,844	20,844	20,844	20,844	31,266	31,266	31,266	31,266
Utility	6,654[l]	8,119	8,119	8,119	8,119	8,119	8,119	8,119	14,773	14,773	14,773	14,773
Cars	1,495	2,990	2,990	2,990	4,790	4,790	6,590	6,590	6,590	6,590	6,590	6,590
Total		54,291	71,993	93,833	95,633	110,193	111,993	119,273	143,629	150,090	169,109	176,389
Buildings[m]												
Operational	177,067[n]	177,067	177,067	196,599	207,327[o]	207,327	207,327	207,327	246,391	246,391	246,391	246,391
Residences	158,359	158,359	158,359	475,078	475,078	475,078	475,078	475,078	490,914	490,914	490,914	490,914
Village & police[p]	6,503	6,503	18,208	44,337	54,471	85,031	104,847	128,679	169,086	215,680	268,910	327,024
Other[q]	-	4,254	5,745	10,008	10,008	11,499	11,499	12,991	17,034	18,525	21,507	22,962
Total		346,183	359,379	726,022	746,884	778,935	798,751	824,075	923,425	971,510	1,027,722	1,087,291
Canals[r]	-	85,677	171,353	425,259	810,534	1,093,806	1,205,086	1,265,439	1,425,000	1,767,000	2,023,500	2,280,000
Total value capital in operation at acquisition price	-	843,384	1,014,483	1,833,595	2,260,871	2,634,021	2,807,312	2,945,188	3,397,023	3,864,340	4,277,057	4,678,144
			Strategy II: Years 1-10									
Additional capital[s] equipment (Ginnery)												
Plant & machinery	-	-	174,146	174,146	174,146	174,146	174,146	174,146	174,146	174,146	174,146	174,146
Building		-	95,532	95,532	95,532	95,532	95,532	95,532	95,532	95,532	95,532	95,532
Total			269,678	269,678	269,678	269,678	269,678	269,678	269,678	269,678	269,678	269,678
Total value capital in operation at acquisition price		-	1,284,161	2,103,273	2,530,549	2,903,699	3,076,990	3,214,866	3,666,701	4,134,018	4,546,735	4,947,822

[a]Total cost for each item of capital investment (not fully depreciated) at acquisition price.

[b]All dollar values for these analyses are U.S. dollars. [c]Tractor depreciation rate: 20 per cent per annum.

[d]Tractor acquisition prices have been averaged assuming standard tractor of 65-70 h.p.: t=0,...,10 acquisition price = $2,688; t=2,...,6 acquisition price = $3,281; t=7,...,10 acquisition price = $3,300.

[e]Equipment and machinery depreciation rate: 10 per cent per annum. [f]Wide-level disc harrow.

[g]Irrigation equipment depreciation rate: 20 per cent per annum.

[h]Plant and machinery depreciation rate: 5 per cent per annum.

[i]Collective acquisition price includes several individual items.

[j]Vehicle depreciation rate: 33 per cent per annum. [k]One station wagon @ $5,189 and one utility car @ $1,465.

[l]One car; in t=3 add 1 car @ $1,800 and in t=5 add another car @ $1,800.

[m]Buildings depreciation rate: 5 per cent per annum.

[n]Includes: Power house @ $41,193, pump house @ $71,286, office and stores @ $45,056, workshop @ $19,532.

[o]In t=3 add school @ $10,728. [p]In t=4 add more accommodation for casual labor and for police authority @ $10,331.

[q]Temporary sheds, stables, fences. [r]No depreciation for canals after construction; only maintenance required.

[s]Ginnery depreciation rate: 5 per cent per annum.

Source: Estimations calculated from Tendaho Plantations Share Company accounts for 1966/67 and 1967/68.

Present Agricultural Economy

The People and Their Habitat

Local inhabitants are groups of nomadic Afar (Danakils) whose way of life is linked to cattle, camels, sheep, and goats. Traditionally, women and children labor; men are concerned only with animal movements. Thus, Afar men are not easily persuaded to undertake field-work which is viewed both as woman's work and as part of the way of life for settled peoples. Some Afar men are employed as guards and watchmen. Since the Tendaho operation is not concerned with settlement, the main labor requirements are met by workers from the surrounding highlands who belong to farming families. These people are able to supplement their own incomes with cash wages earned on the plantations during cotton weeding and harvesting periods.

Highlanders are able to take employment on the plantations after most of their own farm work is over for the season. In the 1967/68 season, approximately 5,600 people were employed in the fields at the height of picking (November), in addition there were 340 regular laborers and 500 more were employed in the ginnery from February-June.

Management consisted of seven expatriates and thirty Ethiopians. The expatriate staff is in charge of the general direction of the plantations; Ethiopian staff manages farm operations and general management duties. Each farm has one manager, one assistant manager, a full complement of regular workers, and day labor as required.

Agricultural Practices

Cotton is the only crop; Acala 1517C variety has been planted throughout the plantations during recent years. Experimentation suggests that Acala 4.42 probably yields equally as well as Acala 1517C and may prove to be better yielding if the supply of water is adequate.[1]

The budget model has been based on an assumption of gradual expansion to 10,000 hectares over the 10 year

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[1]Melka Werer Research Station, Progress Report for the Period February 1966 to March 1968 (Addis Abeba: Institute of Agricultural Research, 1968), p. 6.

operational period. A full complement of sophisticated engine-powered machinery is assumed. Simple hand tools are also necessary and have been included in the inventory of cultivation equipment and machinery shown in Table D.2(a). The quantities of these tools (shovels, spades, pickaxes, used in canal repair and maintenance and in field irrigation) have been estimated on the basis of an approximate cost per hectare under cultivation. Loose tools used in the hand cultivation operations of weeding and thinning are entered as an annual input cost. In the sixth operational year (t=6), farm staff consisted of 30 managers and assistant managers, and 340 regular workers employed over an area of 5,555 hectares divided into units of 12 farms. Since one manager and one assistant farm manager are appointed to each farm, the other 16 individuals are assumed to be members of the general management staff. The 340 regular employees consist of tractor drivers, drivers' assistants, maintenance assistants, and general laborers. The remunerations of all this group of individuals is included in farm staff wages to distinguish them from the wages to field labor which is hired on a daily basis.

Labor and machinery costs for the various field operations are based on data available from the company's accounts for the years 1966/67 and 1967/68. These basic assumptions, recorded in Table D.2(c), are based on a charge of $0.60 per day for hired field labor working an eight-hour day and $4.20[1] per tractor hour for field operations in a working day which varies between 8 and 12 hours.

Production and Value of Crops

Estimates for yields of 5.6 quintals per hectare in the initiating year (t=0) were taken from the practical experience of the plantations. The management realized that yields far in excess of this level can be anticipated, indeed, in excess also of the estimated yield of 16.5 quintals per hectare assumed for the seventh operational yield of the budget model. These assumed yields are recorded in Table D.2(b) along with the prices for the produce.

Tendaho cotton is high quality and the management hopes to export in increasing quantities. The assumed

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[1]Breakdown for this cost is shown in Table D.2(c).

TABLE D.2 Continued
b. Price and annual yield assumptions, budget model (t=0,...,10)

Product	Yield level	Strategy	Price ---$/q.[a]---- (Year: 0-3)	Price (Year: 4-10)	0	1	2	3	4	5	6	7	8	9	10
					Annual yields at indicated year: ---quintals per hectare---										
Area		I,II													
Raw cotton	H	I,II	23.00		5.6	8.0	10.5	12.9	15.4	17.8	20.2	22.7	25.1	27.6	30.0[b]
	L	I,II	23.00		5.6	6.6	7.7	8.7	9.8	10.8	11.8	12.9	13.9	15.0	16.0
					Percentage of yields given for raw cotton yields										
Cotton lint	H,L	II	70.00	72.54	-	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
Cotton seed	H,L	II	8.06	8.06	-	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00

[a] U.S. dollars.

[b] Maximum yield estimate based on data available for Acala 4.42 A, see Carl F. Miller, *et al.*, *Systems Analysis Methods . . .*, pp. 130-49.

The combined production function for cotton is: $Y = Y_m \prod_{i=1}^{8} \phi_i$

The functional terms for ϕ_i are given in Table A.2. Crop production function parameters for the partial response factors for cotton are given as follows:

$$\phi_2 \cdot \phi_3 = e^{-k_t (T-T_m)^2} e^{-k_R (R-R_m)^2},$$

where the given constants are: k_t = .158, K_R = 154, T_m = 27.3, R_m = .138, Y_m = 52.5

and the calculated values are: T = 31.8, R = .100.

$\therefore$ $\phi_2 \cdot \phi_3$ = .5767.

Given $\phi_4 \cdot \phi_5 \cdot \phi_6 = \phi_7 = \phi_8 = 1.00$,

then, $Y = 30.2767$.

TABLE D.2 Continued
c. Estimated annual costs for manual and machine operations, budget model (t=0,...,10)

Operation	Annual operational costs at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a] per quintal										
Manual labor[b]											
Picking	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	dollars[a] per hectare										
Weeding	8.00	8.00	7.46	6.92	6.38	6.38	4.10	4.10	4.10	4.10	4.10
Irrigating	8.00	8.00	7.69	7.38	7.06	6.12	5.18	5.09	4.85	4.75	4.67
Clearing	8.00	8.00	7.07	6.14	5.20	2.20	-	-	-	-	-
Tractor operations[c]											
Disc plowing	5.36	5.36	5.21	5.05	4.90	4.27	4.27	4.15	4.04	4.01	4.00
Planing	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29
Disc harrowing	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
Disc cultivating	5.56	1.56	1.41	1.33	1.19	1.17	1.15	1.14	1.11	1.09	1.07
Planting	1.35	1.35	1.35	1.35	1.35	1.35	.92	.95	.95	.96	.96
Interrow cultivating	5.36	5.36	4.27	3.17	2.09	1.63	1.27	1.25	1.20	1.18	1.16
Clearing	2.14	2.14	2.14	2.14	2.16	3.16	3.64	3.64	3.90	4.07	4.20
Rough plowing	-	-	-	-	-	3.49	3.29	3.20	3.14	3.12	3.10

[a]U.S. dollars. [b]Standard wage of $0.60 per man-day.

[c]Break down of tractor operational costs ($4.20 per tractor-hour) as follows: Fuel, oil and grease, $2.40; maintenance and repairs, $1.40; wages, $0.40.

Source: Tendaho Plantations Share Company accounts for 1966/67 and 1967/68.

price of $70 per quintal for cotton lint is based on the world price for good quality Egyptian cotton during 1963-66 when prices appear to have been stable.[1] The price assumed for raw cotton was that being realized by local cotton producers in 1967.[2]

Technological Improvements

There is no intention in this case to change the level of mechanization. Those operations not already mechanized employ a large quantity of hand labor which would be displaced in the event of increased mechanization. Thus, technological improvement is to be sought in the opportunities for improved operational efficiency in the use of equipment, the utilization of improved cotton varieties, the development of effective pest control programs, and the use of fertilizer where appropriate.

Improvements in Operational Efficiency

There is clear evidence from the records of the plantations that substantial increases in operational efficiency have occurred since the establishment of the plantations. These improvements are reflected in the operational cost data presented in Table D.2(c). Improvements in weeding efficiency have gradually taken place as the plantations have become less weedy; the irrigation operations have been implemented with improving efficiency; hand clearing operations have been gradually eliminated.

The operational efficiency in disc plowing has improved with increasing drivers' skills, improvement in land conditions, and improvements in the layout of the farms. Records show that for the period 1966-1967 an increase of 60 per cent occurred in area and for the period 1966-1968 an increase of 80 per cent occurred. There is no evidence of changing efficiency for planing and harrowing, but some small improvement in efficiency has occurred in the use of the wide-level disc harrow. Significant improvement in planting occurs in the sixth year when six-row planters were introduced, constructed from the four row

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[1] United Nations, Production Year Book, 1966, XX (Rome: Food and Agriculture Organization, 1967), 563.

[2] Carl F. Miller, et al., Systems Analysis Methods . . ., p. 115.

planters previously used. Clearing has been assumed to increase slightly in cost due in the first place to the abandonment of hand clearing and, in the second place, to the fact that in the later years of expansion a higher proportion of rougher land, requiring more clearing, is under cultivation.

Yields

The assumptions for cotton yields recorded in Table D.2(b) are based on data available for Acala 4.42 cotton.[1] Two production levels have been assumed based on high- and low-level yield possibilities. The high-level yields are based on the assumption of reaching maximum attainable yields in the tenth operational year. The lower-level of yield estimates was based on the lower projected boundary of yield fluctuations already experienced on the plantations.

A modest fertilizer program is introduced into the model, beginning in the fourth operational year (t=4). The estimated area of medium growth soil to receive fertilizer amounted to 13 1/2 per cent of the total area under cultivation which received an application of one quintal per hectare of 40:40:0 mixture[2] costing $20.16 per quintal; this was increased annually by 1/2 per cent to reach 16 1/2 per cent in the final operational year.

Crop Protection

Application of insecticides is an important part of the plantations' operational routine. Aircraft are hired for the purpose. The total cost of applying insecticides has been estimated at $37.00 per hectare.

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[1]Carl F. Miller, _et al._, _Systems Analysis Methods . . ._, p. 149.

[2]H. M. Benedict and S. A. Cogswell, _Potential Fertilizer Demand in Ethiopia_, Report No. 1, SRI Project IU--6350, prepared for the Technical Agency of the Imperial Ethiopian Government (Menlo Park, Calif.: Stanford Research Institute, April, 1968), p. 25.

Budgets

Outputs and Inputs

On the basis of the assumptions established in the foregoing discussion the income accounts for the budget model are presented in Table D.3. As in the previous case studies, only the accounts for high level yields are presented in each strategy.

Input accounts are presented in Table D.4. In this case, the input data for high- and low-level production in strategy I are shown instead of the data to correspond directly with the output data in Table D.3. The reason is that inputs for both strategies are exactly the same except for the inclusion of the ginnery in strategy II.

A summary of all the input and output accounts follows in subsequent tables. Table D.5 contains the data on annual crop areas and total annual physical production of cotton; Table D.6 presents a summary of annual incomes from these levels of production.

Table D.7 presents an account of the distribution of labor use in field operations of the plantations. Data in Table D.8 are different from data presented in the corresponding table in other case studies. Since the other inputs of fertilizer and insecticide are only two of a large variety of inputs, many of these are compounded in the input accounts contained in Table D.4. Therefore inputs have been analyzed and presented in terms of the basic components in Table D.8. Finally, the total costs of inputs, excluding financial charges, are summarized in Table D.9.

Financial Costs

Banking and loan arrangements to finance such a large operation are obviously complex. It was assumed that financial accommodation is available from commercial banks and the Development Bank of Ethiopia, and that periodic issues of share capital have been taken up. Prior to the initiating year (t=0) in the budget model there has been an issue of $900,000 worth of equity. Share capital has been increased to $1,100,000 for the third operational year (t=3), and has been increased to $2,472,000 for the fifth operational year (t=5). In the model no dividends have been declared until the third operational year (t=3) when a 6 per cent payment on equity has been made in this and the following year. Subsequently,

TABLE D.3 Tendaho: Annual income accounts, budget model (t=0,...,10)--high-level yields, years 1-10

Year	Crop	Number of farms	Area	Yield	Strategy I		Strategy II				Gross income
							Cotton lint		Cotton seed		
					Production	Gross income	Production	Value (cash)	Production	Value (cash)	
			hectares	q/ha.	quintals	dollars[a]	quintals	dollars[a]	quintals	dollars[a]	dollars[a]
0	Cotton	2	1,100.00	5.6	6,160.00	141,680.00	-	-	-	-	-
					Years 1-10: High-level yields		Years 1-10: High-level yields				
1	Cotton	3	2,165.00	8.0	17,320.00	398,360.00	6,235.00	436,464.00	10,738.40	86,551.50	523,015.50
2	Cotton	5	4,000.00	10.5	42,000.00	966,000.00	15,120.00	1,058,400.00	26,040.00	209,822.40	1,268,282.40
3	Cotton	5	4,000.00	12.9	51,600.00	1,186,800.00	18,576.00	1,300,320.00	31,992.00	257,855.52	1,558,175.52
4	Cotton	6	4,595.00	15.4	70,736.00	1,627,549.00	25,474.68	1,847,933.29	43,873.06	353,616.86	2,201,550.15
5	Cotton	6	5,030.00	17.8	89,534.00	2,059,282.00	32,232.24	2,338,126.69	55,511.08	447,419.30	7,785,545.99
6	Cotton	7	5,555.00	20.2	112,110.00	2,578,530.00	40,359.60	2,927,685.39	69,508.20	560,236.09	3,487,921.48
7	Cotton	8	6,625.00	22.7	150,387.50	3,458,912.00	54,139.50	3,927,279.33	93,240.25	751,516.41	4,678,795.74
8	Cotton	9	7,750.00	25.1	194,525.00	4,474,075.00	70,029.00	5,079,903.66	120,605.50	972,080.33	6,051,983.99
9	Cotton	11	8,875.00	27.6	244,950.00	5,633,850.00	88,182.00	6,396,722.28	151,869.00	1,224,064.14	7,620,786.42
10	Cotton	12	10,000.00	30.0	300,000.00	6,900,000.00	108,000.00	7,834,320.00	186,000.00	1,499,160.00	9,333,480.00

[a]U.S. dollars.

TABLE D.4 Tendaho: Annual input accounts, budget model (t=0,...,10)--strategy I, high- and low-level yields, years 1-10

Year	Tractor field operations[a]	Wages: Field labor	Wages: Farm staff	Seed	Ferti-lizer	Pest control[b]	Field materials	Hand tools[c]	Maintenance: Workshop[d]	Maintenance: Irri-gation[e]	Farm transport	Depreci-ation	Total inputs
	dollars[f]												
0	23,595.00	38,720.00	36,942.00	4,389.00	-	40,700.00	2,443.76	1,969.00	21,679.31	14,212.00	2,186.80	76,899.88	263,736.75
	Strategy I Years 1-10: High-level yields												
1	46,439.25	86,600.00	55,413.00	8,638.35	-	80,105.00	6,620.57	3,875.35	42,668.83	27,971.80	6,148.60	91,541.84	456,022.58
2	80,240.00	172,880.00	92,355.00	15,960.00	-	148,000.00	15,717.00	7,160.00	73,725.28	51,680.00	14,910.00	143,375.19	816,002.47
3	74,880.00	184,960.00	92,355.00	15,960.00	-	148,000.00	19,062.60	7,160.00	68,800.46	51,680.00	18,318.00	146,946.19	828,122.25
4	79,815.15	227,176.80	110,826.00	18,334.05	4,962.60	170,015.00	25,901.56	8,225.05	73,334.92	59,367.40	25,120.86	159,648.84	962,728.23
5	104,372.50	253,009.00	110,826.00	20,069.70	5,633.60	186,110.00	32,560.70	9,003.70	95,898.45	64,987.60	31,784.57	167,625.24	1,081,881.06
6	112,221.00	275,724.00	129,297.00	22,144.50	6,438.00	205,350.00	40,568.83	9,934.50	103,109.72	71,706.00	39,799.05	178,019.24	1,194,311.85
7	132,566.25	361,658.75	147,768.00	26,433.75	7,950.00	245,125.00	54,198.79	11,858.75	121,803.13	85,595.00	53,387.56	215,261.02	1,463,606.00
8	155,155.00	458,412.50	166,239.00	30,922.50	9,610.00	286,750.00	69,884.46	13,872.50	142,557.89	100,130.00	69,056.37	229,702.87	1,732,293.10
9	178,476.25	568,443.75	203,181.00	35,411.25	11,360.00	328,375.00	87,761.32	15,886.25	163,985.68	114,665.00	86,957.25	250,671.37	2,045,174.12
10	201,700.00	687,700.00	221,652.00	39,900.00	13,200.00	370,000.00	107,250.00	17,900.00	185,323.88	129,200.00	106,500.00	267,158.32	2,347,484.20
	Strategy I Years 1-10: Low-level yields												
1	46,439.25	80,538.00	55,413.00	8,638.35	-	80,105.00	5,564.27	3,875.35	42,668.83	27,971.80	5,072.59	91,541.84	447,828.28
2	80,240.00	150,480.00	92,355.00	15,960.00	-	148,000.00	11,813.80	7,160.00	73,725.28	51,680.00	10,934.00	143,375.19	785,723.27
3	74,880.00	151,360.00	92,355.00	15,960.00	-	148,000.00	13,207.80	7,160.00	68,800.46	51,680.00	12,354.00	146,946.19	782,703.45
4	79,815.15	175,712.80	110,826.00	18,334.05	4,962.60	170,015.00	16,933.95	8,225.05	73,334.92	59,367.40	15,986.01	159,648.84	893,161.77
5	104,372.50	182,589.00	110,826.00	20,069.70	5,633.60	186,110.00	20,290.01	9,003.70	95,898.45	64,987.60	19,285.02	167,625.24	986,690.82
6	112,221.00	182,484.00	129,297.00	22,144.50	6,438.00	205,350.00	24,321.76	9,934.50	103,109.72	71,706.00	23,248.95	178,019.24	1,068,274.68
7	132,566.25	231,808.75	147,768.00	26,433.75	7,950.00	245,125.00	31,572.43	11,858.75	121,803.13	85,595.00	30,339.19	215,261.02	1,288,081.27
8	155,155.00	284,812.50	166,239.00	30,922.50	9,610.00	286,750.00	39,634.66	13,872.50	142,557.89	100,130.00	38,242.37	229,702.87	1,497,629.30
9	178,476.25	344,793.75	203,181.00	35,411.25	11,360.00	328,375.00	48,790.31	15,886.25	163,985.68	114,665.00	47,259.37	250,671.37	1,742,855.24
10	201,700.00	407,700.00	221,652.00	39,900.00	13,200.00	370,000.00	58,460.00	17,900.00	185,323.88	129,200.00	56,800.00	267,158.32	1,968,994.20

[a]Fuel and oil, 57.2 per cent; parts and maintenance, 33.3 per cent, and wages, 9.5 per cent.

[b]Salaries, 7 per cent; chemicals, 57 per cent; aircraft hire, 36 per cent.

[c]Baskets, 5-7 per cent; sacking, twine, matting, 93-95 per cent.

[d]Fuel and oil, 43 per cent; parts and maintenance, 25 per cent; wages, 7 per cent; salaries, 8 per cent; materials, 17 per cent.

[e]Wages, 91 per cent; salaries, 9 per cent.

[f]U.S. dollars.

TABLE D.5 Tendaho: Annual crop areas, and total annual production, budget model (t=0,...,10)

Item	Yield level	Strategy	Units	Annual area and production at indicated year										
				0	1	2	3	4	5	6	7	8	9	10
Area		I,II	hectares	1,100.00	2,165.00	4,000.00	4,000.00	4,595.00	5,030.00	5,555.00	6,625.00	7,750.00	8,875.00	10,000.00
Production														
Raw cotton	H	I	quintals	6,160.00	17,320.00	42,000.00	51,600.00	70,736.00	89,534.00	112,110.00	150,387.50	194,545.00	244,950.00	300,000.00
	L		quintals		14,289.00	30,800.00	34,800.00	45,031.00	54,324.00	65,490.00	85,462.50	107,725.00	133,125.00	160,000.00
Lint	H	II	quintals	-	6,235.00	15,120.00	18,576.00	25,474.68	32,232.24	40,359.60	54,139.50	70,029.00	88,182.00	108,000.00
	L		quintals		5,144.00	11,088.00	12,528.00	16,211.16	19,556.64	23,576.40	30,766.50	38,781.00	47,925.00	57,600.00
Seed	H	II	quintals	-	10,738.40	26,040.00	31,992.00	43,873.06	55,511.08	69,508.20	93,240.25	120,605.50	151,869.00	186,000.00
	L		quintals		8,589.18	19,096.00	21,576.00	27,919.22	33,680.88	40,603.80	52,986.75	66,789.50	82,537.00	99,200.00

TABLE D.6 Tendaho: Summary of annual gross incomes, budget model (t=0,...,10)

Product	Annual gross incomes at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Raw cotton	141,680.00	398,360.00	966,000.00	1,186,800.00	1,627,549.00	2,059,282.00	2,578,530.00	3,485,912.50	4,474,075.00	5,633,850.00	6,900,000.00
		Strategy I Years 1-10: Low-level yields									
Raw cotton	-	328,647.00	708,400.00	800,400.00	1,035,713.00	1,249,452.00	1,506,270.00	1,965,637.50	2,477,675.00	3,061,875.00	3,680,000.00
		Strategy II Years 1-10: High-level yields									
Cotton lint	-	436,464.00	1,058,400.00	1,300,320.00	1,847,933.29	2,338,126.69	2,927,685.39	3,927,279.33	5,079,903.66	6,396,722.28	7,834,320.00
Cotton seed	-	86,551.50	209,882.40	257,855.52	353,616.86	447,419.30	560,236.09	751,516.41	972,080.33	1,224,064.14	1,499,160.00
Total	-	523,015.50	1,268,282.40	1,558,175.52	2,201,550.15	2,785,545.99	3,487,921.48	4,678,795.74	6,051,983.99	7,620,786.42	9,333,480.00
		Strategy II Years 1-10: Low-level yields									
Cotton lint	-	360,082.80	776,160.00	876,960.00	1,175,957.55	1,418,638.67	1,710,232.06	2,231,801.91	2,813,173.74	3,476,479.50	4,178,304.00
Cotton seed	-	71,404.99	153,913.76	173,902.56	225,028.91	271,467.89	327,266.62	427,073.20	583,323.37	665,252.25	799,552.00
Total		431,487.79	930,073.76	1,050,862.56	1,400,986.46	1,690,106.56	2,037,498.68	2,658,875.11	3,351,497.11	4,141,731.75	4,977,856.00

[a]U.S. dollars.

TABLE D.7 Tendaho: Annual labor use in field operations, budget model (t=0,...,10)

Field operation	0	1	2	3	4	5	6	7	8	9	10
	Annual field labor requirements at indicated year										
	man-days										
	Strategy I Years 1-10: High-level yields										
Manual labor											
Weeding[a]	14,667	28,867	49,733	46,133	48,860	53,486	37,925	45,271	52,958	60,646	68,333
Irrigating[a]	14,667	28,867	51,267	49,200	54,068	51,306	47,915	56,202	62,646	70,260	77,833
Picking[a]	13,689	38,489	93,334	114,667	157,251	198,964	249,133	334,194	432,278	544,334	666,667
Clearing[a]	14,666	28,866	47,133	40,933	39,823	18,443	-	-	-	-	-
Total	57,689	125,089	241,467	250,933	300,002	322,199	334,973	435,667	547,882	675,240	812,833
Tractor operations											
(1 man) Plowing (disc)[b]	140	276	496	481	536	511	564	655	746	846	952
(2 men) Planing[b]	225	442	817	817	939	1,028	1,134	1,353	1,583	1,813	2,043
(1 man) Discing[b]	36	72	132	132	152	166	184	219	256	294	331
(1 man) Cultivating[b]	41	81	134	127	130	140	152	180	205	230	255
(2 men) Planting[c]	60	101	214	214	246	270	202	250	292	338	380
(2 men) Row cultivating[a]	351	691	1,017	755	572	488	420	493	554	623	690
(1 man) Clearing[b]	56	110	204	204	236	378	481	574	720	860	1,000
(1 man) Rough plowing[b]	-	-	-	-	-	418	435	505	579	659	738
Total	909	1,773	3,014	2,730	2,811	3,399	3,572	4,229	4,935	5,664	6,389
Transport (truck)	1,458	4,099	9,940	12,212	16,674	21,190	26,532	35,592	46,038	57,972	71,000
Total field labor	60,056[d]	130,961	254,421	265,875	319,487	346,788	365,077	475,488	598,855	738,876	890,222
	Strategy I Years 1-10: Low-level yields										
Total manual labor		118,353	216,578	213,600	242,820	243,955	231,373	291,390	354,993	426,740	501,722
Total tractor labor		1,773	3,014	2,730	2,811	3,399	3,572	4,229	4,935	5,664	6,389
Transport		3,382	7,289	8,236	10,657	12,857	13,833	20,226	25,495	31,506	37,867
Total field labor		123,508	226,881	224,566	256,288	260,211	248,778	315,845	385,423	463,910	545,978
	Strategy II Years 1-10: High-level yields										
Total field labor		130,961	254,421	268,875	319,487	346,788	365,077	475,488	598,855	738,876	890,222
Ginnery		6,178	14,982	18,406	25,244	31,938	39,991	53,645	69,389	87,377	107,014
Total labor		137,139	269,403	287,281	344,731	378,726	405,068	529,133	668,244	826,253	997,236
	Strategy II Years 1-10: Low-level yields										
Total field labor		123,508	226,881	224,566	256,288	260,211	248,778	315,845	385,423	463,910	545,978
Ginnery		5,097	10,987	12,414	16,063	19,378	23,361	30,485	38,427	47,487	57,074
Total labor		128,605	237,868	236,980	272,351	279,589	272,139	346,330	423,850	511,397	603,052

[a] Eight hour working day. [b] Ten hour working day. [c] Twelve hour working day.

[d] Total field labor wage bill: 57,689 m-d @ $0.60 + 909 m-d @ $1.40 + 1,458 m-d @ $0.60 = $36,760.80.

TABLE D.8 Tendaho: Analysis of annual inputs, budget model (t=0,...,10)

Input	0	1	2	3	4	5	6	7	8	9	10
	Annual inputs at indicated year										
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Salaries	89,194.12	104,503.97	122,431.75	130,972.12	143,868.48	159,701.95	174,917.15	192,160.03	208,161.16	226,867.59	245,037.18
Wages	130,668.37	216,740.78	372,509.28	387,280.29	460,770.48	500,230.16	554,013.90	681,935.40	822,479.02	995,884.12	1,160,796.52
Fuel and oils	23,635.94	47,220.78	83,219.10	79,333.61	86,688.60	112,955.90	123,587.11	148,414.76	176,201.32	205,544.03	235,416.41
Parts & maintenance	13,765.92	27,499.65	48,458.19	46,190.07	50,465.37	65,758.05	71,940.22	86,384.80	102,550.21	119,619.10	136,994.30
Seeds	4,389.00	8,638.35	15,960.00	15,960.00	18,334.05	20,069.70	22,144.50	26,433.75	30,922.50	35,411.25	39,900.00
Chemicals	23,199.00	45,659.85	84,360.00	84,360.00	96,908.55	106,082.70	117,049.50	139,721.25	163,447.50	187,173.75	210,900.00
Fertilizers	-	-	-	-	4,962.60	5,633.60	6,438.00	7,950.00	9,610.00	11,360.00	13,200.00
Field materials	2,443.76	6,620.57	15,717.00	19,062.60	25,901.56	32,560.70	40,568.83	54,198.79	69,884.46	87,761.32	107,250.00
Hand tools	1,969.00	3,875.35	7,160.00	7,160.00	8,225.05	9,003.70	9,934.50	11,858.75	13,872.50	15,886.25	17,900.00
Aircraft	14,652.00	28,837.80	53,280.00	53,280.00	61,205.40	66,999.60	73,926.00	88,245.00	103,230.00	118,215.00	133,200.00
Materials	103,354.20	114,191.92	127,726.40	132,754.73	140,673.88	151,816.86	160,669.19	172,142.29	183,827.21	196,327.43	208,811.09
Administration & sales	33,134.81	48,525.97	79,354.20	93,686.16	119,107.27	144,090.00	173,717.96	221,344.51	276,005.39	338,226.93	406,204.14
Miscellaneous financial	7,296.40	8,107.05	9,007.96	10,008.96	11,120.98	12,233.00	13,456.31	14,801.81	16,281.98	17,910.09	19,701.24
Total	447,702.52	660,422.04	1,019,183.88	1,060,048.54	1,228,232.27	1,387,135.92	1,542,363.17	1,845,591.14	2,176,473.25	2,556,186.86	2,935,310.88
Depreciation	76,899.88	91,541.84	143,375.19	146,946.19	159,648.84	167,625.24	178,019.24	215,261.02	229,702.89	250,671.37	267,158.32
Total costs	524,602.40	751,963.88	1,162,559.07	1,206,994.73	1,387,881.11	1,554,761.16	1,720,382.41	2,060,852.16	2,406,176.14	2,806,858.23	3,202,469.20
		Strategy I Years 1-10: Low-level yields									
Salaries		104,503.97	122,431.75	130,972.12	143,868.48	159,701.95	174,917.15	192,160.03	208,161.16	226,867.59	245,037.18
Wages		210,248.38	348,518.88	351,294.69	405,652.53	424,810.34	454,153.86	542,866.05	636,553.42	756,354.97	860,916.52
Fuel and oils		46,811.90	81,708.22	77,067.29	83,217.35	108,206.07	117,298.07	139,656.38	164,492.00	190,458.83	216,530.41
Parts & maintenance		27,262.93	47,583.47	44,877.99	48,455.70	63,008.15	68,299.20	81,314.15	95,771.13	110,885.57	126,060.30
Seeds		8,638.35	15,960.00	15,960.00	18,334.05	20,069.70	22,144.50	26,433.75	30,922.50	35,411.25	39,900.00
Chemicals		45,659.85	84,360.00	84,360.00	96,908.55	106,082.70	117,049.50	139,721.25	163,447.50	187,173.75	210,900.00
Fertilizers		-	-	-	4,962.60	5,633.60	6,438.00	7,950.00	9,610.00	11,360.00	13,200.00
Field materials		5,564.27	11,813.80	13,207.80	16,933.95	20,290.01	24,321.76	31,572.43	39,634.66	48,790.31	58,460100
Hand tools		3,875.35	7,160.00	7,160.00	8,225.05	9,003.70	9,934.50	11,858.75	13,872.50	15,886.25	17,900.00
Aircraft		28,837.80	53,280.00	53,280.00	61,205.40	66,999.60	73,926.00	88,245.00	103,230.00	118,215.00	133,200.00
Materials		114,191.92	127,726.40	132,754.73	140,673.88	151,816.87	160,669.19	172,142.29	183,827.21	196,327.43	208,811.09
Administration & sales		45,137.91	66,834.84	74,907.12	90,344.06	104,732.26	121,606.12	148,771.34	178,980.37	213,228.95	249,712.14
Miscellaneous financial		8,107.05	9,007.96	10,008.96	11,120.98	12,233.00	13,456.31	14,801.81	16,281.98	17,910.09	19,701.24
Total		648,839.68	976,385.32	995,850.70	1,129,902.58	1,252,587.95	1,364,214.16	1,597,493.23	1,844,784.43	2,128,869.99	2,400,328.88
Depreciation		91,541.84	143,375.19	146,946.19	159,648.84	167,625.24	178,019.24	215,261.02	229,702.87	250,671.37	267,158.32
Total costs		740,381.52	1,119,760.51	1,142,796.89	1,289,551.42	1,420,213.19	1,542,233.40	1,812,754.25	2,074,487.30	2,379,541.36	2,667,487.20
		Strategy II Years 1-10: High-level yields									
Salaries		113,290.40	143,738.35	157,148.80	179,766.55	205,122.54	231,790.55	268,451.61	306,843.69	351,130.73	397,227.18
Wages		220,440.33	381,480.48	398,302.05	475,885.45	519,354.63	577,960.60	714,058.17	864,029.56	1,048,205.44	1,224,876.52
Fuel and oils		47,220.78	83,219.10	79,333.61	86,688.60	112,955.90	123,587.11	148,414.76	176,201.32	205,544.03	235,416.41
Parts & maintenance		29,349.42	52,943.79	51,700.95	58,022.86	75,320.28	83,913.57	102,446.18	123,325.48	145,779.76	169,034.30
Seeds		8,638.35	15,960.00	15,960.00	18,334.05	20,069.70	22,144.50	26,433.75	30,922.50	35,411.25	39,900.00
Chemical		45,659.85	84,360.00	84,360.00	96,908.55	106,082.70	117,049.50	139,721.25	163,447.50	187,173.75	210,900.00
Fertilizers		-	-	-	4,962.60	5,633.60	6,438.00	7,950.00	9,610.00	11,360.00	13,200.00
Field materials		6,620.57	15,717.00	19,062.60	25,901.56	32,560.70	40,568.83	54,198.79	69,884.46	87,761.32	107,250.00
Hand tools		3,875.35	7,160.00	7,160.00	8,225.05	9,003.70	9,934.50	11,858.75	13,872.50	15,886.25	17,900.00
Aircraft		28,837.80	53,280.00	53,280.00	61,205.40	66,999.60	73,926.00	88,245.00	103,230.00	118,215.00	133,200.00
Material		114,191.92	127,726.40	132,754.73	140,673.88	151,816.87	160,669.19	172,142.29	183,827.21	196,327.43	208,811.09
Ginnery sacks		31,908.65	77,376.60	95,062.68	130,366.66	164,948.49	206,540.25	277,058.89	358,373.41	451,271.38	552,690.00
Administration & sales		54,584.22	94,045.12	111,735.01	147,003.73	179,386.43	217,914.38	280,630.83	352,691.79	434,792.94	524,471.27
Miscellaneous finances		8,107.06	9,007.96	10,008.96	11,121.00	12,233.00	13,456.31	14,801.81	16,281.98	17,910.09	19,701.24
Total		712,724.70	1,146,014.80	1,215,869.39	1,445,065.94	1,661,488.14	1,885,893.29	2,306,412.08	2,772,541.40	3,306,768.47	3,854,578.01
Depreciation		113,733.04	165,566.39	169,137.39	181,840.04	189,816.44	200,210.44	237,452.22	251,894.07	272,862.57	289,349.52
Total costs		826,457.75	1,311,581.19	1,385,006.78	1,626,905.98	1,851,304.58	2,086,103.73	2,543,864.30	3,024,435.47	3,579,631.04	4,143,927.53
		Strategy II Years 1-10: Low-level yields									
Salaries		111,752.78	138,056.59	148,626.16	166,712.71	187,260.51	208,140.22	235,515.16	262,810.05	294,401.91	326,205.18
Wages		213,300.51	355,097.76	358,727.97	415,271.15	436,413.95	468,142.53	561,120.84	659,563.48	784,790.47	895,092.52
Fuels and oils		46,811.90	81,708.22	77,067.29	83,217.35	108,206.07	117,298.07	139,656.38	164,492.00	190,458.83	216,530.41
Parts & maintenance		28,788.99	50,872.91	48,594.63	53,265.01	68,809.95	75,293.53	90,441.55	107,276.16	125,103.32	143,148.30
Seeds		8,638.35	15,960.00	15,960.00	18,334.05	20,069.70	22,144.50	26,433.75	30,922.50	35,411.25	39,900.00
Chemicals		45,659.85	84,360.00	84,360.00	96,908.55	106,082.70	117,049.50	139,721.25	163,447.50	187,173.75	210,900.00
Fertilizer		-	-	-	4,962.60	5,633.60	6,438.00	7,950.00	9,610.00	11,360.00	13,200.00
Field materials		5,564.27	11,813.80	13,207.80	16,933.95	20,290.01	24,321.76	31,572.43	39,634.66	48,790.31	58,460.00
Hand tools		3,875.35	7,160.00	7,160.00	8,225.05	9,003.70	9,934.50	11,858.75	13,872.50	15,886.25	17,900.00
Aircraft		28,837.80	53,280.00	53,280.00	61,205.40	66,999.60	73,926.00	88,245.00	103,230.00	118,215.00	133,200.00
Materials		114,191.92	127,726.40	132,754.73	140,673.88	151,816.87	160,669.19	172,142.29	183,827.21	196,327.43	208,811.09
Ginnery sacks		26,324.62	56,742.84	64,112.04	82,960.61	100,081.11	120,652.23	157,447.56	198,461.77	245,256.19	294,768.00
Administration & sales		50,135.98	77,608.18	87,079.60	108,096.33	126,148.07	147,423.84	182,462.69	221,448.13	265,709.98	312,787.94
Miscellaneous finances		8,107.06	9,007.96	10,008.96	11,121.00	12,233.00	13,456.31	14,801.81	16,281.98	17,910.09	19,701.24
Total		691,989.38	1,069,394.66	1,100,939.18	1,267,887.64	1,419,048.84	1,564,890.18	1,859,369.46	2,174,877.94	2,536,794.78	2,890,604.68
Depreciation		113,733.04	165,566.39	169,137.39	181,840.04	189,816.44	200,210.44	237,452.22	251,894.07	272,862.57	289,349.52
Total costs		805,722.42	1,234,961.05	1,270,076.57	1,449,727.68	1,608,865.28	1,765,100.62	2,096,821.68	2,426,772.01	2,809,657.35	3,179,954.20

[a]U.S. dollars.

TABLE D.9 Tendaho: Summary of annual total costs for inputs (excluding financial charges), budget model (t=0,...,10)

Item	Annual total inputs at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Total inputs	263,763.75	456,022.58	816,002.47	828,122.25	962,728.23	1,081,881.06	1,194,311.85	1,463,606.00	1,732,293.10	2,045,174.12	2,347,484.20
Marketing	6,885.65	19,360.30	46,947.60	57,678.48	79,098.88	100,081.10	125,316.56	168,103.15	217,440.04	273,805.11	335,340.00
Administration[b]	253,980.00	276,581.00	299,609.00	321,194.00	346,054.00	372,799.00	400,754.00	429,143.00	456,443.00	487,879.00	519,645.00
Total costs	524,602.40	751,963.88	1,162,559.07	1,206,994.73	1,387,881.11	1,554,761.16	1,720,382.41	2,060,852.16	2,406,176.14	2,806,858.23	3,202,469.20
		Strategy I Years 1-10: Low-level yields									
Total inputs		447,828.28	785,723.27	782,703.45	893,161.77	986,690.82	1,068,274.68	1,288,081.27	1,497,629.30	1,742,855.24	1,968,994.20
Marketing		15,972.24	34,428.24	38,899.44	50,335.65	60,723.37	73,204.72	95,529.98	120,415.00	148,807.12	178,848.00
Administration		276,581.00	299,609.00	321,194.00	346,054.00	372,799.00	400,754.00	429,143.00	456,443.00	487,879.00	519,645.00
Total costs		740,381.52	1,119,760.51	1,142,796.89	1,289,551.42	1,420,213.19	1,542,233.40	1,812,754.25	2,074,487.30	2,379,541.36	2,667,487.20
		Strategy II Years 1-10: High-level yields									
Strategy I inputs		456,022.58	816,002.47	828,122.25	962,728.23	1,081,881.06	1,194,311.85	1,463,606.00	1,732,293.10	2,045,174.12	2,347,484.20
Ginnery		46,244.40	112,140.00	137,772.00	188,937.21	239,055.78	299,333.70	401,534.62	519,381.75	654,016.50	801,000.00
Add depreciation		22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20
Total inputs		524,458.18	950,333.67	988,085.45	1,173,856.64	1,343,128.04	1,515,836.75	1,887,331.82	2,273,866.05	2,721,381.82	3,170,675.40
Marketing		25,418.55	61,638.52	75,727.33	106,995.34	135,377.54	169,512.98	227,389.47	294,126.42	370,370.22	453,607.13
Administration		276,581.00	299,609.00	321,194.00	346,054.00	372,799.00	400,754.00	429,143.00	456,443.00	487,879.00	519,645.00
Total costs		826,457.74	1,311,581.19	1,385,006.78	1,626,905.98	1,851,304.58	2,086,103.73	2,543,864.30	3,024,435.47	3,579,631.04	4,143,927.53
		Strategy II Years 1-10: Low-level yields									
Strategy I inputs		447,828.28	785,723.27	782,703.45	893,161.77	986,690.82	1,068,274.68	1,288,081.27	1,497,629.30	1,742,855.24	1,968,994.20
Ginnery		38,151.63	82,236.00	92,916.00	120,232.77	145,045.08	174,858.30	228,184.87	387,625.75	355,443.75	427,200.00
Add depreciation		22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20	22,191.20
Total inputs		508,171.11	890,150.47	897,810.65	1,035,585.74	1,153,927.10	1,265,324.18	1,538,457.34	1,807,446.25	2,120,490.19	2,418,385.40
Marketing		20,970.31	45,201.58	51,071.92	68,087.94	82,139.18	99,022.44	129,221.33	162,882.76	201,288.16	241,923.80
Administration		276,581.00	299,609.00	321,194.00	346,054.00	372,799.00	400,754.00	429,143.00	456,443.00	487,879.00	519,645.00
Total costs		805,722.42	1,234,961.05	1,270,076.57	1,449,727.68	1,608,865.28	1,765,100.62	2,096,821.68	2,426,772.01	2,809,657.35	3,179,954.20

[a]U.S. dollars.

[b]Administration expenses itemized as follows: medical expenses, $5,000 (salaries, 82%; material, 18%); plantation headquarters expenses, $48,825 (salaries, 79%; administration, 21%); engineering expenses, $12,456 (salaries, 100%); power house expenses, $40,512 (wages, 39%; salaries, 61%); engineering maintenance, $107,596 (wages, 11%; materials, 89%); agronomy, $11,528 (wages, 85%; materials, 15%); Addis Abeba HQ, $28,063 (salaries, 17%; administration, 57%; miscellaneous financial, 26%); marketing (shown separately), $6,885.65 (administration, 100%).

annual dividends of 12 per cent have been paid. This situation follows the actual experience of the company fairly closely except for the payment of dividends. In reality there was no payment of dividends for six years in succession from the commencement of operations, a situation which the shareholders felt was unreasonable.

Share capital subscriptions are assumed to be used entirely for the purchase of items on the capital inventory. Total capital requirements (new purchases of capital equipment and replacement of depreciated equipment) have been computed annually, and the unused balance of share capital applied to this expenditure. In operational years of the budget model ($t=1,\ldots,10$) the depreciation account fund was also applied to the expenditure on capital equipment. Unused balances of funds have accrued interest at 4 per cent per annum and overdrawals on available funds have been accommodated by a medium-term loan in which the amount of funds needed was amortized at 7 per cent per annum over a period of seven years.

A crop loan is used annually to finance the operational costs until the sale of the annual crop at the end of the season. Interest on the crop loan has been charged on a monthly basis at the rate of 8 per cent per annum.

Any residual cash balances from previous years were intended to be used as available cash for operational expenses. In fact, the budget model for the first ten years of operation shows no available cash balances to be carried forward into the next operating period.

Finally, overdraft accommodation has been assumed. Any cash deficits accrued in the previous year of operation are brought forward into the current operating year as a cost to be repaid at an interest rate of 7 per cent per annum.[1] The operation runs at a cash deficit for each operational year of the budget model until the ninth year ($t=9$) on the high-level yield assumptions. Thus, in the tenth year the overdraft charge, the largest single charge in each year of operation, will have reached its maximum and this charge will then disappear in the following year. Financial charges and net financial costs are shown in Table D.10.

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[1]Assumed rates of interest are compatible with the policies of the Ethiopian commercial banks and the Development Bank of Ethiopia. Harry J. Robinson and Ato Mammo Bahto, op. cit., p. 187.

TABLE D.10 Tendaho: Annual financial charges and net financial costs, budget model (t=0,...,10)

Item	Annual financial charges and costs at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
		Strategy I Years 1-10: High-level yields									
Overdraft	-	466,968.03	680,914.71	1,043,157.85	1,087,216.87	1,260,435.13	1,436,932.16	1,606,140.21	1,915,743.86	2,252,697.11	2,639,511.70
Interest on crop loan	60,215.20	85,703.91	127,519.83	130,807.73	148,995.46	170,735.88	188,026.01	219,185.15	252,681.54	290,833.90	327,294.37
Medium term loan	-	6,937.67	119,135.03	198,873.50	16,155.71	61,048.90	100,547.72	204,442.68	281,657.34	258,808.70	330,758.24
Div. on share capital	-	-	-	66,000.00	148,320.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00
Total financial charges	60,215.20	559,645.61	927,569.57	1,438,839.08	1,400,688.04	1,788,859.91	2,326,408.05	2,326,408.05	2,746,722.74	3,098,979.71	3,594,204.31
less interest earned	2,264.64	-	-	-	-	-	-	-	-	-	-
Net financial costs	57,950.56	559,645.61	927,569.57	1,438,839.08	1,400,688.04	1,788,859.91	2,326,408.05	2,326,408.05	2,746,722.74	3,098,979.71	3,594,204.31
		Strategy I Years 1-10: Low-level yields									
Overdraft		466,968.03	669,672.91	1,001,617.71	1,024,906.67	1,164,996.66	1,306,340.35	1,433,299.38	1,674,940.87	1,930,761.03	2,224,759.37
Interest on crop loan		85,136.46	125,423.01	127,662.50	144,178.02	164,144.00	179,298.00	207,030.16	236,431.20	269,898.48	301,084.14
Medium term loan		6,973.67	119,135.03	198,873.50	16,155.71	61,048.90	100,547.72	204,442.68	281,657.34	258,808.71	330,758.24
Div. on share capital		-	-	66,000.00	148,320.00	296,640.00	296,460.00	296,640.00	296,640.00	296,640.00	296,640.00
Net financial costs		559,078.16	914,230.95	1,394,153.71	1,333,560.40	1,686,829.56	1,882,826.07	2,141,342.22	2,489,669.41	2,756,108.22	3,153,241.75
		Strategy II Years 1-10: High-level yields									
Overdraft		466,968.03	736,878.56	1,178,866.94	1,253,945.18	1,492,447.15	1,730,489.02	1,973,717.44	2,408,822.28	2,890,490.00	3,442,634.02
Interest on crop loan		93,048.08	145,329.00	244,795.47	179,442.52	209,259.50	236,263.36	283,892.09	336,379.44	396,228.09	397,076.19
Medium term loan		57,013.29	165,057.01	152,687.58	62,077.69	106,970.87	146,469.70	250,364.66	277,539.69	258,808.71	330,758.24
Div. on share capital		-	-	66,000.00	148,320.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00
Net financial costs		617,029.40	1,047,264.57	1,642,349.99	1,643,785.39	2,105,317.52	2,409,862.08	2,804,614.19	3,319,381.41	3,842,166.78	4,467,108.45
		Strategy II Years 1-10: Low-level yields									
Overdraft		466,968.03	715,843.08	1,101,137.71	1,137,351.34	1,312,640.67	1,484,453.50	1,647,952.72	1,955,148.43	2,283,961.03	2,661,238.89
Interest on crop loan		91,195.40	138,483.07	142,418.68	163,553.43	187,517.89	207,476.26	243,801.95	282,781.83	327,177.92	369,927.04
Medium term loan		57,013.29	165,057.01	244,795.47	62,077.69	106,970.87	146,469.70	250,364.66	277,539.69	258,808.71	330,758.24
Div. on share capital		-	-	66,000.00	148,320.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00	296,640.00
Net financial costs		615,176.72	1,019,383.16	1,554,351.86	1,511,302.46	1,903,769.43	2,135,039.46	2,438,759.33	2,812,109.95	3,166,587.71	3,658,564.17

[a]U.S. dollars.

Budget Summary

The accounts of the budget model are summarized in Table D.11. In this case, no additional requirements, outside the budgets, are necessary to run the operation.

TABLE D.11 Tendaho: Summary of budget model accounts (t=0,...,10)

Item	Annual account summary at indicated year										
	0	1	2	3	4	5	6	7	8	9	10
	dollars[a]										
	Strategy I Years 1-10: High-level yields										
Gross income	141,680.00	398,360.00	966,000.00	1,186,800.00	1,627,549.00	2,059,282.00	2,578,530.00	3,458,912.50	4,474,075.00	5,633,850.00	6,900,000.00
less total costs[b]	524,602.40	751,963.88	1,162,559.07	1,206,994.73	1,387,881.11	1,554,761.16	1,720,382.41	2,060,852.16	2,406,176.14	2,806,858.23	3,202,469.20
Net returns	-382,922.40	-353,603.88	-196,559.07	-20,194.73	-239,667.89	-504,520.84	-858,147.59	1,398,060.34	2,067,898.86	2,826,991.77	3,697,530.80
less net fin. costs	57,950.56	559,645.61	927,569.57	1,438,839.08	1,400,688.04	1,733,859.91	2,022,145.89	2,326,408.05	2,746,722.74	3,098,979.71	3,594,204.31
Net income	-440,872.96	-913,249.49	-1,124,128.64	-1,459,033.81	-1,161,020.15	-1,284,399.07	-1,163,998.30	-928,347.70	-678,823.88	-271,987.94	103,326.49
	Strategy I Years 1-10: Low-level yields										
Gross income		328,647.00	708,400.00	800,400.00	1,035,713.00	1,249,452.00	1,506,270.00	1,965,637.50	2,477,675.00	3,061,875.00	3,680,000.00
less total costs[b]		740,381.52	1,119,760.51	1,142,796.89	1,289,551.42	1,420,213.19	1,542,233.40	1,812,754.25	2,074,487.30	2,379,541.36	2,667,487.20
Net returns		-411,734.52	-411,360.51	-342,396.89	-253,838.42	-170,761.19	-35,963.40	152,883.25	503,187.70	682,333.64	1,012,512.80
less net fin. costs		559,078.16	914,230.95	1,394,153.71	1,333,560.40	1,686,829.56	1,882,826.07	2,141,342.22	2,489,669.41	2,756,108.22	3,153,241.75
Net income		-970,812.68	-1,325,591.46	-1,736,550.60	-1,587,398.82	-1,857,590.75	-1,918,789.47	-1,988,458.97	-2,086,481.72	-2,073,774.57	-2,140,728.95
	Strategy II Years 1-10: High-level yields										
Gross income		523,015.50	1,268,282.40	1,558,175.52	2,201,550.15	2,785,545.99	3,487,921.47	4,678,795.74	6,051,983.99	7,620,786.42	9,333,480.00
less total costs[b]		826,457.74	1,311,581.19	1,385,006.78	1,626,905.98	1,851,304.58	2,086,103.73	2,543,864.30	3,024,435.47	3,579,631.04	4,143,927.53
Net returns		-303,442.24	-43,298.79	173,168.74	574,644.17	934,241.41	1,401,817.74	2,134,931.44	3,027,548.52	4,041,155.38	5,189,552.47
less net fin. costs		617,029.40	1,047,264.57	1,642,349.99	1,643,785.39	2,105,317.52	2,409,862.08	2,804,614.19	3,319,381.41	3,842,166.78	4,467,108.45
Net income		-920,471.64	-1,090,563.36	-1,469,181.25	-1,069,141.22	-1,171,076.11	-1,008,044.34	-669,682.75	-291,832.89	198,988.60	722,444.02
	Strategy II Years 1-10: Low-level yields										
Gross income		431,487.79	930,073.76	1,050,862.56	1,400,986.46	1,690,106.56	2,037,498.68	2,658,875.11	3,351,497.11	4,141,731.75	4,977,856.00
less total costs[b]		805,722.42	1,234,961.05	1,270,076.57	1,449,727.68	1,608,865.28	1,765,100.62	2,096,821.68	2,426,772.01	2,809,657.35	3,179,657.35
Net returns		-374,234.63	-304,887.29	-219,214.01	-48,741.22	81,241.28	272,398.06	562,053.43	924,725.10	1,332,074.40	1,797,901.80
less net fin. costs		615,176.72	1,019,383.16	1,554,351.86	1,511,302.46	1,903,769.43	2,135,039.46	2,438,759.32	2,812,109.95	3,166,587.71	3,658,564.17
Net income		-989,411.34	-1,324,270.45	-1,773,565.87	-1,560,043.68	-1,822,528.15	-1,862,641.39	-1,876,705.89	-1,887,384.84	-1,834,513.30	-1,860,662.37

[a]U.S. dollars. [b]Excludes financial costs.

APPENDIX E

INTERVIEW SCHEDULE

APPENDIX E

INTERVIEW SCHEDULE

Account of Current Practices on Individual Farms

1. Farmer (name, location, size of family, number of dependents, level of education).

2. Soil (type, condition, general topography).

3. Climate (rainfall, temperature, sunshine, humidity, evaporation).

4. Indigenous plants.

5. Tenure arrangements.

6. Land use (total area, crop distribution).

7. Crop enterprises (crops, crop year, inventories, yields, sales, consumption, sequence of operations, labor utilization fertilization, pest control, seeds).

8. Livestock enterprises (animals, inventories, production, purchases, sales, family consumption, death, labor utilization, other products, feeding).

9. Labor (family, hired, unpaid).

10. Power and transport (hand, oxen, tractors, trucks, mules, donkeys, inventories, purchases, sales, deaths, tractor hire use, fuel requirements).

11. Machinery, implements, equipment (hand tools, animal/tractor tools and equipment, inventories, purchases, sales, depreciation, owned, hired).

12. Buildings (home and farm, storage bins).

13. Taxation expenses.

14. Additional funds (fuel refunds, other employment, loans).

15. Market (distance, mode of travel, frequency of visits, items bought and sold).

16. Miscellaneous (fencing and drainage work, holidays observed, household expenditures).

APPENDIX F

SELECTED DATA FROM BENEFIT-COST ANALYSES

TABLE F.1 Data required for evaluation of benefit-cost criteria from budget data (t=0,...,10) high production level using 10 per cent discount rate by case, Ethiopia

Year	Computed data required for evaluation of NPV, IRR, B/C, NPV/K						Additional data for evaluation of NPV/T_W, NPV/T_{WS}			
	Total revenue (TR)	Sum PVTR[a]	Capital cost (K)	Operating costs (O)	Sum PVTC[b]	NPV[c]	Salary[d] costs (T_W)	Other[d] costs	Salary and support (T_{WS})	Other[d] costs
	dollars[e]						dollars[e]		dollars[e]	
a. Agnale Village (run 1)										
0	4,497	4,497	118	2,862	2,980	1,517	-	2,980	-	2,980
1	4,606	8,684	2,787	3,081	8,314	370	300	5,568	753	5,115
2	4,698	12,567	1,645	2,749	11,945	621	310	4,084	461	3,933
3	4,822	16,190	1,902	2,469	15,230	960	320	4,051	470	3,901
4	8,794	22,196	335	4,194	18,323	3,873	330	4,199	784	3,745
5	12,325	29,849	18	4,282	20,993	8,856	340	3,960	491	3,809
6	15,459	38,575	80	3,999	23,296	15,280	340	3,739	490	3,589
7	18,384	48,009	387	4,006	25,550	22,459	350	4,043	803	3,590
8	20,950	57,782	142	4,038	27,500	30,282	350	3,830	501	3,679
9	23,354	67,687	66	4,113	29,272	38,415	360	3,819	510	3,669
10	25,560	77,541	325	4,209	31,020	46,521	360	4,174	813	3,721
	Criteria evaluation		NPV	46,521			NPV/T_W	22.89	NPV/T_{WS}	12.54
			IRR	> 400						
			B/C	2.50						
			NPV/K	7.57						
b. Agnale Village (run 2)										
0	-	-	118	-	118	118	-	118	-	118
1	109	99	2,787	219[f]	2,850	-2,752	300	2,706	753	2,253
2	201	265	1,645	-113	4,116	-3,851	310	1,222	461	1,071
3	325	509	1,902	-393	5,250	-4,741	320	1,189	470	1,039
4	4,297	3,444	335	1,332	6,389	-2,945	330	1,337	784	883
5	7,828	8,305	18	1,420	7,282	1,023	340	1,098	491	947
6	10,962	14,493	80	1,137	7,969	6,524	340	877	490	727
7	13,887	21,619	387	1,144	8,754	12,865	350	1,181	803	728
8	16,453	29,294	142	1,176	9,369	19,925	350	968	501	817
9	18,857	37,292	66	1,251	9,927	27,364	360	957	510	807
10	21,063	45,412	325	1,347	10,572	34,840	360	1,312	813	859
	Criteria evaluation		NPV	38,840			NPV/T_W	17.14	NPV/T_{WS}	9.39
			IRR	0.611						
			B/C	4.30						
			NPV/K	5.67						
c. Chilalo Awraja: Strategy I (run 1)										
0	330	330	558	270	828	-498	-	828	-	828
1	536	817	35	460	1,277	-460	41	453	75	419
2	779	1,462	9	608	1,787	-326	43	574	56	561
3	992	2,206	9	729	2,341	-135	44	694	58	680
4	1,132	2,980	26	798	2,904	76	45	779	80	744
5	1,271	3,769	-	872	3,446	323	47	825	61	811
6	1,344	4,527	133	911	4,035	492	47	997	60	984
7	1,418	5,255	45	954	4,548	707	48	951	83	916
8	1,477	5,944	330	986	5,162	782	48	1,269	62	1,255
9	1,560	6,606	5	1,033	5,603	1,003	49	989	64	974
10	1,634	7,236	21	1,073	6,025	1,211	50	1,044	84	1,010
	Criteria evaluation		NPV	1,211			NPV/T_W	4.33	NPV/T_{WS}	2.92
			IRR	0.397						
			B/C	1.20						
			NPV/K	1.37						
d. Chilalo Awraja: Strategy II (run 1)										
0	330	330	100	270	370	-40	-	370	-	370
1	576	853	703	648	1,598	-745	142	1,209	263	1,088
2	833	1,542	32	784	2,273	-731	149	667	197	619
3	1,147	2,403	32	948	3,009	-606	154	826	203	777
4	1,311	3,299	92	1,015	3,766	-467	158	949	279	828
5	1,474	4,214	16	1,090	4,452	-238	163	943	212	894
6	1,554	5,092	463	1,128	5,350	-259	163	1,428	211	1,380
7	1,633	5,930	109	1,171	6,007	-77	168	1,112	290	990
8	1,695	6,720	3	1,201	6,569	152	168	1,036	216	988
9	1,787	7,478	16	1,245	7,103	375	173	1,088	222	1,039
10	1,868	8,198	73	1,248	7,631	586	173	1,148	294	1,027
	Criteria evaluation		NPV	586			NPV/T_W	0.60	NPV/T_{WS}	0.40
			IRR	0.218						
			B/C	1.08						
			NPV/K	0.48						
e. Chilalo Awraja: Strategy I (run 2)										
0	213	213	558	174	732	-519	-	732	-	732
1	419	594	35	363	1,094	-500	41	357	75	323
2	662	1,141	9	512	1,525	-384	43	478	56	465
3	875	1,798	9	633	2,007	-208	44	598	58	584
4	1,015	2,492	26	702	2,504	-12	45	683	80	648
5	1,154	3,208	-	776	2,986	222	47	729	61	715
6	1,227	3,901	133	815	3,522	380	47	901	60	888
7	1,301	4,568	45	858	3,985	584	48	855	83	820
8	1,360	5,203	330	890	4,554	649	48	1,172	62	1,158
9	1,443	5,815	5	937	4,954	861	49	893	64	878
10	1,517	6,400	21	977	5,339	1,061	50	948	84	914
	Criteria evaluation		NPV	1,061			NPV/T_W	3.80	NPV/T_{WS}	2.55
			IRR	0.353						
			B/C	1.20						
			NPV/K	1.20						

Year	Total revenue (TR)	Sum PVTR[a]	Capital cost (K)	Operating costs (O)	Sum PVTC[b]	NPV[c]	Salary[d] costs (T_W)	Other[d] costs	Salary and support (T_{WS})	Other[d] costs
	Computed data required for evaluation of NPV, IRR, B/C, NPV/K						Additional data for evaluation of NPV/T_W, NPV/T_{WS}			
	dollars[e]						dollars[e]		dollars[e]	
f. Chilalo Awraja: Strategy II (run 2)										
0	213	213	100	174	274	-61	-	274	-	274
1	459	630	703	552	1,415	-785	142	1,113	263	992
2	716	1,222	32	688	2,010	-788	149	571	197	523
3	1,030	1,996	32	852	2,675	-679	154	730	203	681
4	1,194	2,811	92	919	3,365	-554	158	853	279	732
5	1,357	3,654	16	994	3,992	-338	163	847	212	798
6	1,437	4,465	463	1,032	4,836	-371	163	1,332	211	1,284
7	1,516	5,243	109	1,075	5,444	-200	168	1,016	290	894
8	1,578	5,979	3	1,105	5,960	19	168	940	216	892
9	1,670	6,687	16	1,149	6,455	233	173	992	222	943
10	1,750	7,362	73	1,152	6,927	435	173	1,052	294	931
Criteria evaluation			NPV	435			NPV/T_W	0.45	NPV/T_{WS}	0.30
			IRR	0.184						
			B/C	1.06						
			NPV/K	0.36						
g. Setit-Humera: Strategy I										
0	69,197	69,197	21,898	69,391	91,289	-22,092	-	91,229	-	91,289
1	82,764	144,437	225	81,354	165,452	-21,014	90	81,489	158	81,421
2	90,514	219,242	20	83,206	234,233	-14,991	93	83,133	125	83,101
3	96,466	291,718	17	81,196	295,249	- 3,531	96	81,117	128	81,085
4	102,661	361,837	3,043	82,413	353,617	- 8,220	99	85,357	168	85,288
5	108,242	429,047	12,603	78,956	410,468	18,579	102	91,457	134	91,425
6	114,280	493,555	4	80,326	455,812	37,743	102	80,228	134	80,196
7	120,017	555,143	39	81,451	497,629	57,513	105	81,385	173	81,317
8	126,292	614,059	3,004	82,648	537,587	76,472	105	85,547	137	85,515
9	131,952	670,020	4	83,622	573,052	96,967	108	83,518	140	83,486
10	138,203	723,303	17,635	84,619	612,475	110,827	108	102,146	177	102,077
Criteria evaluation			NPV	110,827			NPV/T_W	181.79	NPV/T_{WS}	123.55
			IRR	0.15						
			B/C	1.18						
			NPV/K	2.75						
h. Setit-Humera: Strategy II										
0	69,197	69,197	37,536	69,391	106,927	-37,730	-	106,927	-	106,927
1	82,823	144,491	36	69,960	107,559	-26,068	90	69,906	158	69,838
2	91,346	219,983	21	72,772	230,718	-10,735	93	72,699	125	72,667
3	98,196	293,759	873	70,766	284,541	9,218	96	71,543	128	71,511
4	104,420	365,080	3,063	71,922	335,757	29,323	99	74,886	168	74,817
5	110,028	433,398	12,623	68,721	386,265	47,133	102	81,242	134	81,210
6	116,149	498,961	44	69,832	425,708	73,253	102	69,774	134	69,742
7	121,917	561,524	58	70,893	462,117	99,407	105	70,846	173	70,778
8	127,940	621,209	3,026	71,873	497,058	124,151	105	74,794	137	74,762
9	133,643	677,887	-	72,641	527,865	150,022	108	72,533	140	72,501
10	140,118	731,908	33,193	73,428	568,972	162,936	108	106,513	177	106,444
Criteria evaluation			NPV	162,936			NPV/T_W	267.27	NPV/T_{WS}	181.65
			IRR	0.579						
			B/C	1.29						
			NPV/K	2.61						
i. Tendaho Plantations: Strategy I										
0	141,680	141,680	843,384	447,702	1,291,086	-1,149,406	89,194	1,201,892	154,603	1,136,483
1	398,360	503,825	171,099	660,422	2,047,014	-1,543,189	104,504	727,017	140,504	691,017
2	966,000	1,302,173	819,112	1,019,184	3,566,267	-2,264,095	122,432	1,715,864	258,512	1,579,784
3	1,186,800	2,193,833	481,567	1,060,049	4,724,506	-2,530,673	130,973	1,410,643	232,664	1,308,952
4	1,627,549	3,305,471	390,852	1,228,232	5,830,362	-2,524,891	143,868	1,475,216	222,750	1,396,334
5	2,059,282	4,584,123	254,645	1,417,744	6,868,784	-2,284,661	159,702	1,512,687	239,542	1,432,847
6	2,578,530	6,039,636	220,847	1,542,363	7,864,070	-1,824,434	174,917	1,588,293	279,928	1,483,282
7	3,458,924	7,814,611	730,314	1,845,591	9,103,811	-1,289,201	192,160	2,223,745	294,576	2,121,329
8	4,474,075	9,901,800	490,957	2,176,473	10,348,187	-446,387	208,161	2,459,269	295,401	2,372,029
9	5,633,850	12,291,102	495,774	2,556,187	11,642,517	648,586	226,868	2,825,093	353,399	2,698,562
10	6,900,000	14,951,351	833,459	2,935,311	13,097,468	1,853,883	245,037	3,528,733	368,355	3,405,415
Criteria evaluation			NPV	1,853,883			NPV/T_W	1.74	NPV/T_{WS}	1.08
			IRR	0.187						
			B/C	1.14						
			NPV/K	0.51						
j. Tendaho Plantations: Strategy II										
0	141,680	141,680	843,384	447,703	1,291,086	-1,149,406	89,194	1,201,893	154,603	1,136,484
1	523,015	617,148	440,777	712,725	2,339,725	-1,722,577	113,290	1,040,212	149,290	1,004,212
2	1,268,282	1,665,315	819,112	1,146,015	3,963,797	-2,298,482	143,738	1,821,389	279,818	1,685,309
3	1,558,176	2,835,996	481,567	1,215,869	5,239,106	-2,403,110	157,149	1,540,287	258,840	1,438,596
4	2,201,550	4,339,684	390,852	1,445,066	6,493,063	-2,153,378	179,767	1,656,151	258,649	1,577,269
5	2,785,546	6,069,289	254,645	1,661,488	7,682,830	-1,613,541	205,123	1,711,010	284,918	1,631,215
6	3,487,921	8,038,129	220,847	1,885,893	8,872,030	-833,901	231,791	1,874,949	336,802	1,769,938
7	4,678,796	10,439,092	570,314	2,306,412	10,348,246	90,846	268,452	2,608,274	370,868	2,505,858
8	6,051,984	13,262,387	490,957	2,771,541	11,870,225	1,392,162	306,844	2,955,654	394,084	2,868,414
9	7,620,786	16,494,344	495,774	3,306,768	13,482,874	3,011,470	351,131	3,451,411	477,662	3,324,880
10	9,333,480	20,092,804	838,459	3,854,578	15,292,243	4,800,562	397,227	4,295,810	520,545	4,172,492
Criteria evaluation			NPV	4,800,562			NPV/T_W	3.45	NPV/T_{WS}	2.36
			IRR	0.287						
			B/C	1.31						
			NPV/K	1.23						

[a]Sum Present Value Total Revenue $\left(= \sum_{t=0}^{t} \frac{TR_t}{(1+i)^t} \right)$. [b]Sum Present Value Total Costs $\left(= \sum_{t=0}^{t} \frac{(Ot+Kt)}{(1+i)^t} \right)$.

[c]Net Present Value (= Sum PVTR - Sum PVTC).

[d](Salary costs + other costs) = K+O; thus, for NPV/T_W and NPV/T_{WS}, Sum PVTC has same value as sum PVTC for evaluation of NPV, IRR, B/C, and NPV/K.

[e]Dollar values for these analyses are U.S. dollars.

[f]Small errors in addition due to rounding to nearest digit.

[g]Negative operating costs due to economies in inputs which reduce operating costs below level required for subsistence production which has been deducted in run 2.

APPENDIX G

RESULTS FROM SENSITIVITY ANALYSES

TABLE G.1 Financial performance criteria computed for given changes in six selected parameters in benefit-cost analyses of four Ethiopian cases (parameter changes--increases in: total product, labor input, discount rate; increasing trends in: output, and labor input)

Case	Strategy	NPV	PB	IRR	B/C	NPV/K	NPV/T_W	NPV/T_{WS}	Scale factor at which B/C=1	NPV	PB	IRR	B/C	NPV/K	NPV/T_W	NPV/T_{WS}
		dollars[a]	year	%	-------dollar ratio[a]--------					dollars[a]	year	%	------dollar ratio---------			
		1. Increase in total product: Scale factor = 1.40[b]								2. Increase in labor input: Scale factor = 1.40[a]						
Agnale		53,005	5	75.7	6.01	8.63	26.08	14.28	0.24	28,721	6	42.0	2.72	4.68	14.13	7.74
Chilalo	I	3,621	2	87.8	1.68	4.10	12.96	8.72	0.84	464	7	21.2	1.08	0.52	1.66	1.12
	II	3,380	3	85.4	1.49	2.78	3.47	2.33	0.94	81	10	11.5	1.01	0.07	0.08	0.06
Setit-Humera	I	400,148	<1	>400	1.65	9.94	656.37	446.10	0.83	29,705	>10	2.1	0.96	-0.74	-48.72	-33.12
	II	455,700	1	>400	1.80	7.30	747.49	508.03	0.76	48,067	7	21.2	1.07	0.77	78.75	153.59
Tendaho	I	7,834,423	6	40.8	1.60	2.15	7.35	4.58	0.88	1,144,747	9	15.4	1.08	0.31	1.07	0.67
	II	12,837,684	5	52.9	1.84	3.30	9.92	6.30	0.76	4,091,424	8	26.0	1.26	1.05	2.94	2.01
		3. Increase in discount rate: i=.15								4. Increase in foreign exchange rate = 20%[c]						
Agnale		23,844	6	61.1	3.69	4.29	14.47	7.87		33,468	5	60.3	4.24	5.53	16.75	9.16
Chilalo	I	697	5	35.3	1.16	0.87	3.08	2.06		1,041	5	34.9	1.20	1.18	3.75	2.52
	II	143	8	18.4	1.03	0.13	0.18	0.12		211	9	14.4	1.03	0.17	0.25	0.12
Setit-Humera	I	77,680	4	51.0	1.15	2.31	160.09	108.77		92,892	4	46.6	1.17	2.31	160.09	108.77
		118,131	3	57.9	1.25	2.23	238.84	162.29		139,058	3	52.7	1.27	2.23	238.84	162.29
Tendaho	I	620,128	9	18.7	1.06	0.20	0.72	0.45		1,418,338	9	17.0	1.11	0.39	1.52	0.92
	II	2,744,071	8	28.7	1.22	0.82	2.49	1.68		4,092,026	8	26.8	1.28	1.05	3.08	2.08
		5. Increasing trend in output: B=.015[d]								6. Increasing trend in labor input:[f] B=.015[d]						
Agnale		39,922	5	64.6	4.78	6.50	19.65	10.76		20,231	7	38.4	1.80	3.29	9.96	5.45
Chilalo	I	1,587	4	42.2	1.30	1.80	5.68	3.82		-1,131	>10	<0	0.85	-1.28	-4.05	-2.72
	II	1,046	7	27.6	1.15	0.86	1.07	0.72		-766	>10	<0	0.91	-0.63	-0.79	-0.53
Setit-Humera	I	161,599	3	62.2	1.26	4.01	263.07	180.15		73,930	5	40.7	1.11	1.91	121.27	82.42
	II	214,440	3	65.7	1.38	3.43	351.75	239.06		133,381	3	52.4	1.22	2.14	218.79	148.70
Tendaho	I	1,920,035[e]	9	18.9[e]	1.15[e]	0.53[e]	1.80[e]	1.12[e]		1,689,597	9	18.0	1.13	0.46	1.58	0.98
	II	6,855,936	7	33.9	1.45	1.76	4.92	3.37		4,636,276	7	28.2	1.30	1.19	3.33	2.28

[a] All dollar values in these analyses are U.S. dollars.

[b] Scale factor increases selected output, or input by 40 per cent.

[c] Benefit-cost analyses recomputed with cost of imported equipment increased by 20 per cent.

[d] Trend effect obtained by price function incorporated into the program: $P = A + B(t)$. When $A = 1.0$, and $B = .015$, then increasing trend effect in output is 1.5 per cent per annum.

[e] In case of Tendaho (strategy I), in the price function $P = A + B(t)$, $P = 23$. Therefore, relative changes in benefit-cost criteria computed from data in this table were adjusted by x 23 to put on the comparative basis shown in Table 22.

[f] Each case employs a different price for labor. Therefore, relative changes in benefit-cost criteria computed from data in this table were adjusted according to the following values for A (in the price function $P = A + B(t)$) to put on the comparative basis shown in Table 22. Agnale: $A = .06$; Chilalo: $A = .05$; Setit-Humera: $A = .61$; Tendaho: $A = 1.0$.

APPENDIX H

UNITS OF MEASURE AND CURRENCY

APPENDIX H

UNITS OF MEASURE AND CURRENCY

Units of Measure

1. Area

1 hectare (ha.) = 2.47 acres

2. Weight

1 kilogram (kg.)	= 2.20	pounds
1 metric quintal (q.)	= 100	kilograms
	= 220	pounds
1 metric ton	= 0.98	long tons = 2240 pounds
	1.10	short tons= 2000 pounds
	=1000	kilograms

3. Yield

100 kilograms per hectare (kg./ha.) = 1.49 bushels (60 pounds) per acre

4. Liquid Measure

1 liter (l.) = 0.26 U.S. gallons

5. Length

1 meter (m.)	= 1.09 yards
1 kilometer (km.)	= 0.62 miles
1 centimeter (cm.)	= 2.54 inches

Units of Currency

E$1.00 = U.S. $0.40   U.S. $1.00 = E$2.50

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