TECHNICAL REPORT NO. 12

FEASIBILITY STUDIES AND EVALUATION OF IRRIGATION PROJECTS:

PROCEDURES FOR ANALYZING ALTERNATIVE WATER DISTRIBUTION SYSTEMS IN EGYPT

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EGYPT WATER USE AND MANAGEMENT PROJECT

22 El Galaa St., Bulak, Cairo, Egypt

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PREFACE

The authors of this report have outlined a process for comparing the various systems employed for the distribution of irrigation water. It is hoped that the ideas presented will serve as a useful tool for those who wish to evaluate — and eventually to implement — irrigation programs. For this reason it is the method, rather than the results obtained, which should hold the attention of the reader. Offering a coherent methodology is the primary purpose of the authors, and all results presented herein are to serve merely as examples of that method in action.

The report opens with a brief discussion of benefit/cost analyses, followed by a description of the use of partial budgets (a related, but simplified approach) for the analysis of proposed modifications in the water distribution systems in Egypt. An example of the partial budget analysis in action follows, an actual case study of a site in Minya Governorate. The report concludes with a discussion of various ways to extend the usefulness of the analytical methods described, as, for example, using them to help identify gaps in essential information or to design innovative solutions to problems long known.

Please note that the procedures described in this paper were specifically designed to facilitate the analysis of conditions in Egypt's water distribution system as they exist today. The method itself centers on the use of a set of worksheets such as those presented in III.A.3 and Appendix A. Demonstrations of applications of the procedure are shown in Appendices E and F.

The worksheets, then, form the core of the report. They are the tool provided by the authors to be used in the analysis of irrigation systems, and the rest of the report is a manual designed to instruct the reader on their proper use. Still, it must be remembered that worksheets are not a product in themselves, but only a simple and efficient way to analyze important information.

As a final note, the authors wish to point out that, whereas partial budgets--dealt with at length in the body of this report--are a simplified method when compared to more conventional benefit/cost studies, both approaches result in a similar ranking of projects in the majority of cases. The partial budget analysis seems to be the more appropriate to conditions which prevail in Egypt today, but for further information on traditional benefit/cost analyses, see numbers 7, 9 and 10 in the List of References on Page 58. Various systems of project analysis presently in use by international, national and private agencies, which do not come under the purview of this report, could be extremely helpful in the development of a standardized routine for a regular process of project evaluation.

Today's Egypt offers a host of opportunities for rehabilitating her existing irrigation system and for developing systems in the new lands. One cannot stress too much the magnitude of the social benefits which will accrue to the Egyptian people if an effective program for project analysis is adopted. This can only occur, however, if project analysis is seen as an interdisciplinary effort, involving irrigation engineers, agronomists, sociologists, economists and other experts in related fields. We offer this report as a example of an operational procedure and have stressed the importance of developing good baseline data and project response data on which to base important decisions.

It is the authors' hope that their report will serve as a useful aid, both in facilitating the making of good decisions based on sound factual data, and in providing a method for documenting the basis for those decisions.

Feasibility Studies and Evaluation of Irrigation Projects:

Procedures for Analyzing Alternative Water Distribution Systems in Egypt

I. Benefit/Cost Analysis and the Criteria for Evaluation of Proposed Changes in Water Distribution Systems

A. Net Present Value

To analyze probable benefits and costs from proposed changes in a water distribution system, it is necessary to compare.

a. Benefits which are expected to accrue to the system's users (projected over a period of years in the future)

with

b. Costs

1. Construction costs needed to effect changes

2. Additional recurring costs associated with operating and maintaining the system.

The result of such a comparison is the system's net present value, which is the generally accepted basis for benefit/cost analysis. (For the standard formula used to calculate the net present value, see Appendix B below.)

The procedure generally recommended for benefit/cost analysis is to calculate the net present value for each of the alternatives being considered. The alternative which shows the highest net present value is the best and should be implemented, but the accuracy of the calculations will depend on the degree to which the benefits and costs can be expressed in monetary terms, and the presence or absence of complicating factors. Furthermore, even where adequate information exists to calculate net present values for all alternatives, some factors will remain nonquantifiable and will not be accounted for in the calculations. Decision-makers must be careful not to use net present value calculations in a vacuum, but to consider supplementary information as well before choosing to implement changes in their irrigation system.

Sassone and Schaffer [10, p. 29],* in discussing various benefit/cost criteria, state:

> "The net present value criterion is generally accepted as the proper decision criterion to be used in cost/benefit analysis."

(For general discussions of alternative criteria, net present value, the benefit cost/ratio, internal rate of return and the pay-off period as elements of benefit/cost analysis, see the List of References, 7, 9, 10).

If the calculation of net present value is in principle the soundest method of benefit/cost analysis, however, it often leaves something to be desired in fact. It is, for instance, often difficult to obtain the data necessary for the calculations, and the authors have suggested the following modification of the net present value criterion as one which is better suited to conditions as they exist in Egypt today.

B. Al Riba: The issue of interest rates in a Muslim society

Selecting appropriate interest rates of discount rates in a benefit/cost study presents major problems in all situations. This issue has been the subject of long and unresolved controversy [10, Chapter 6]. In the field of economics, it is generally agreed that the appropriate use of discount rates is the key to the efficient use of capital resources. Interest rates are designed to compensate the investor for the likely gains

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* Bracketed numbers refer to bibliographic items contained in the List of References at the end of this report.

he could make by investing his capital elsewhere, i.e., the capital's opportunity cost [3, Chapter 4].

The Koran does not question either the contribution capital can make in the production of new wealth or the justification of people who own capital to benefit from its productive use. A person who invests capital has a right to share in any profits which that capital helps to generate, but he is also expected to share in any losses which might occur. Investment of capital in productive investments is encouraged. What is forbidden is the specification of a predetermined and fixed rate of return on capital, regardless of what happens to the investment funded by that capital. Benefit/cost analysis, however, is based on the use of predetermined interest rates.

For this reason, the issue of al-riba, or usury, which is forbidden in Muslim religious law, further complicates the use of net present value calculations [8, p. 180] in Muslim countries. The difference between "usury" and "interest" has not been resolved in these countries. Although there seems to be agreement that, in some cases, the charging of a moderate interest is appropriate, some Muslim thinkers believe that the government should not charge interest on any of its operations. Even many traditionalists agree, however, that limited interest charges may be made on foreign loans, if such charges are unavoidable. Many Egyptian irrigation improvements are funded by low-interest loans from international sources, and the use of an appropriately low discount rate in these cases may involve less of an ideological conflict. Currently, a 4% discount rate for government operation seems to be a compromise acceptable to most parties.

In the case of individuals, the question of the appropriate interest rate is even more involved. The Egyptian farmer faces serious problems associated with capital rationing. It seems likely that the marginal return on private capital investments in agriculture are high, but definitive studies on this issue are not available. Once again, many traditionalists recognize the problem and agree that concealed interest is allowable. Given present conditions, a 10% discount rate for private operations in Egyptian benefit/cost studies seems reasonable. (For a more detailed discussion on how interest rates are used, see below. Appendix C: Depreciation and Interest Costs.)

Most conventional project analysis contains provisions for explicit, predetermined interest rates. This is true for project analyses in Egypt and other Muslim countries, despite the fact that many Muslims contend that the practice is contrary to a strict interpretation of religious law. Yet the idea of the opportunity cost for capital is not unacceptable to Muslims. Since explicit, predetermined interest rates are just one method of expressing the immensely complex problem of the opportunity cost of capital, economists working in Muslim countries should look to other avenues which are not objectionable to the people. Benefit/cost analyses are, after all, simplified models of the economic situation, and this particular method of simplification, i.e. the expression of the opportunity cost for capital in terms of a fixed interest or discount rate, will almost inevitably lead to awkwardness in Muslim societies, and may even mean the rejection of otherwise acceptable plans.

C. Al Zakah: The issue of equity in a Muslim Society

The issue of equity--who gets what from whom--is an essential part of all benefits/cost studies. It is, however, an issue which will never be resolved definitively, being as it is an ethical question dependent on the mores of the society rather than an economic one. In Muslim contexts, this already complex problem is further complicated by the existence of al zakah. Strictly speaking, al zakah is an alms tax, or tithe, and it is one of the "five pillars" of Islam. It is generally agreed that al zakah reflects Islam's special concern for fairness towards individuals. Al zakah is an attempt to equalize wealth and eliminate poverty, for in the ideal Muslim society, poverty would not exist. For this reason, irrigation projects which are designed to help poor farmers on small plots to achieve a better economic condition are ideally looked upon with especial favor in Muslim countries.

Due to the complex, non-quantifiable nature of the problem, no attempt was made to measure the changes in equity nor to place a value on such changes in the present study. When developing projects for actual use, however, decision-makers will have to consider issues of equity and fairness as well as those of economic and technological feasibility.

II. A Simplified Approach: Partial-Budget Analysis

Partial-budget analysis can be used to evaluate water distribution projects, for it is a modification of the net present value criterion discussed above. For the purpose of analyzing proposed water management projects in Egypt today, the authors suggest that the analysis be based on the average annual benefits and costs. It is true that this method could give misleading results if either (a) the incidence of benefits and costs varied significantly through time for the different possible alternatives, or (b) the useful lifespans of the proposed alternatives were different. The authors advocate this method, however, in view of the difficulty of obtaining reasonably reliable estimates for even average annual costs in regard to changes in mesgas and canals in Egypt. Estimates for the benefits and costs for a series of time intervals simply do not exist. (For a more detailed discussion for the reasons behind this recommendation, see Appendix B: Average Annual Benefits and Costs as a Decision-Making Criterion).

A partial budget was used in a preliminary analysis of the proposed El-Hammami pipeline and for improvements to Mesqa 10; Appendices E and F, respectively. (1) Brown (3, Chapter 3) advances this as a method suitable for studying farm income as well as for project analysis. Martin Upton (12, Chapter 15) discusses the partial budget as it applies in a more restrictive situation.

Upton suggests partial budget analysis be presented in three parts:

PART 1. Specification

The Specification is a brief statement of all possible alternatives. It must contain enough information so that representatives of different disciplines can understand which systems are being compared. In the case of water delivery systems, the existing system can serve as the basis for comparisons, but only where good base data is available. This requires that adequate information be gathered on the farming system as it exists before any interventions take place. Experience in Egypt suggests that the base data should include information on crop rotations, yields, farming practices, irrigation practices (with special attention to type of labor used), amount of water applied, and type of water lifting methods. The specification, then, is a concise statement of the problem and its possible solutions.

PART 2. Changes in the System

A partial budget concentrates on identifying the parts of a system which are open to change. By implication, this implies that other parts of the system will not change or will not change significantly. In part II, the multidisciplinary evaluation team reaches agreement about which changes they will examine in their preliminary analysis. Results of the preliminary analysis may show that the various aspects of the system should be rearranged in order of importance and during the next round of analysis, some parts should receive more and some should receive less attention than originally planned. In most cases, a feasibility study will go through at least one or two such rounds. (See IV.A for further discussion of this issue).

Some changes in the system may not lend themselves to analysis of the type presented in Part 3, below. Changes of this type should be noted, and the appropriate analysis, sometimes quantitative and sometimes qualitative, should be presented as part of the final analysis. For example, the task of raising a mesqa might be the impetus for starting a Farmer Organization which, in turn, would be likely to produce significant spinoff benefits. Many of these benefits, however, cannot be measured in monetary terms. The word "incommensurable" has been suggested for changes of this type (10, p. 34).

PART 3. Estimated Benefits to Cost Equation

General categories for the analysis of the benefits and costs resulting from proposed changes are:

Benefits	Costs
A. Added Benefits (resulting from proposed change).	C. Increased Costs (resulting from proposed change).
B. Reduced Costs (costs eliminated by proposed change).	D. Loss of Existing Benefits (resulting from changes in the present system).
TOTAL BENEFITS = (A + B)	TOTAL COSTS = (C + D)

(TOTAL BENEFITS - (TOTAL COSTS) = NET BENEFITS

A combination of the NET BENEFITS (as calculated in Part 3) and an evaluation of those features which do not lend themselves to partial budget analysis (as discussed in Part 2) forms the basis for judging the desirability of a proposed change. When considering a number of alternatives, a partial budget must be constructed for each alternative. This task may be simplified, however, by treating closely related alternatives as variables of a single basic partial budget.

Partial budgets involve considerable work, but they offer the analyst a systematic method for discovering mistakes while a project is still in the planning stage. Every alternative for changing an irrigation system which is a serious candidate for implementation warrants at least a partial-budget analysis. The quality of the decisions which follow will depend largely on the quality of the work put into the partial budget's construction. Used correctly, partial-budget analysis should help to insure that a change in an irrigation system will be successful and that the country's resources will be used wisely.

B. Partial Budget Worksheets

The authors have included worksheets for the information of the reader as illustrations of the way to gather data for preparing partial budgets. Since every change proposed for a water delivery system will be tailored to the peculiarities of the particular site, every change will require a site-specific analysis. For this reason, the worksheets provided in Appendix A below should not be regarded as forms to be completed in every situation, but rather as models on which to pattern each new partial budget.

The sample worksheets include two closely related proposals (designated as a and b) for improvements on Mesqa 26 near El-Minya.

C. Partial-Budget Analysis and Economic Levels

The partial budget may be constructed on the basis of average annual costs and average annual benefits for most feasibility studies on Egyptian water distribution improvement projects. More elaborate analysis probably which would show expected benefits and costs for specific time periods is not justified due to the paucity of the information available. It is necessary to determine the average value of investments in order to calculate interest costs when average annual benefits and costs are used in the analysis. Average values of other benefit and cost factors should also be used. Appendix B contains more information on average annual benefit/cost analyses. Appendix C deals with depreciation and interest costs.

It is important to specify the economic level at which benefits and costs are calculated. For example, domestic prices to Egyptian farmers in 1979 for major trade crops such as cotton and rice were only 40 to 50% of international prices, while domestic livestock prices were 10 to 20% higher than international prices (2, 4, 5). In addition, many of the Egyptian farmer's purchases are subsidized by the government, and his costs do not reflect true economic costs. In the case of cotton, the government subsidy amounts to about 30% of variable costs. The subsidy on purchased inputs for most grain crops is approximately 15 to 20% of variable costs (4, 5). The estimated benefits and costs of a change in a farming system are affected by this governmental modification of both absolute and relative price levels. The terms financial and economic are sometimes used to specify the level at which the analysis is conducted (7).

The impact of relative economic levels on benefit-cost analysis results is greater if there are changes in the crop rotation. Even if it is assumed that crop rotation remains unchanged, however, the evaluation of changes in amount of land farmed, or in average yield will all depend on the price level used to evaluate these changes.

In the case of Egypt, the value of a change at the farm level (financial or private benefits) is generally significantly less than the value of the same change assessed at the national level (economic or public benefits). Public benefits accrue to the society or the nation while private benefits are realized by the farmer and those directly affected by the change in question. For example, the average annual net value of increases in cotton production will be about 50% greater if assessed at the national level rather than assessed from the prices received for the same crop at the farm level.

D. Problems -- Applied Economics

As analysts gain experience with any method, they become aware of areas, both conceptual and empirical, which merit special concern. Such areas may have been identified a having a higher likelihood of significant error, or of being of a complexity which would lead to opportunities being overlooked. Three such areas present themselves to our attention at this time:

1. The Estimation of Investment Costs and the Effects of Depreciation and Interest Costs

A significant portion of the increased average annual cost associated with improving water distribution systems consists of the annual depreciation, maintenance and interest costs. The level of these costs is, in turn, very much dependent on the amount of investment, i.e. the investment costs, required to change the existing water distribution system. A feasibility study should be conducted early enough to influence the decision about what kind of changes to make, and estimates of the investment costs must be used in the analysis.

Generally speaking, increased precision in the estimation of investment costs will require increased effort on the part of the analysts. Judgment should be used to weight the trade-off between the added benefits from more precise estimates of investment costs against the effort involved in obtaining them. During the early stages of analyzing a project, investment costs estimated to within 10 to 20% of actual investment costs may suffice. Project implementors can gain insight into the degree of precision required by using sensitivity analysis, as set forth in IV. B, below.

Adherence to a few simple principles will decrease the likelihood of repeated, systematic biases in the estimation of investment costs. These principles cannot be applied mechanically, however, but will require the exercise of judgment on the part of the analyst.

The decision to include or not to include a cost as part of the investment costs should be made on the basis of whether the costs are variable or fixed. Variable costs are those costs which are incurred as the result of undertaking the project. That is, if the project were not undertaken, these costs would have been avoided. Fixed costs will exist regardless of any action on the part of the project. Variable costs should be included as part of investment costs; fixed costs should not.

The classification of costs as fixed or variable, however, will depend on the level at which an analysis is being made (see Partial Budgets and Economic Levels). For example, the design costs for raising a mesqa would not generally be a variable cost to the farmers who are served by the mesqa, unless the Ministry of Irrigation required the farmers to repay the Ministry for the design effort. Design costs would, however, be a variable cost to be considered at the Ministry level, since they would most likely be paid for with resources which could have been used elsewhere to produce goods and services of social value. (In the case of EWUP pilot projects, at least some of the design costs can be classified as research costs, and therefore need not be included in the estimated investment costs calculated for feasibility studies of the pilot projects. Generally, however, design costs are a part of investment costs.)

It should be noted when calculating expected investment costs in Egypt that, in most situations, the Ministry of Irrigation has the responsibility for supervising the construction work done by a contractor. Often supervision costs will amount to 10 to 20% of the total investment costs. If the costs of construction supervision are considered to be variable costs, they must be included as part of the total investment costs when calculating depreciation and capital costs.

Another area which should not be overlooked is the increase in management costs which often takes place after construction of an irrigation improvement has been completed. These costs are not part of the initial investment costs, but they should be included in the analysis as increased costs. This hold true, of course, only if they are variable costs given the economic level of the analysis.

Annual depreciation costs ought to reflect the yearly decrease in the value of an investment which occurred as the result of use during that year. Such costs are calculated by means of a depreciation formula, but it should be noted that there are a number of variables which may cause the real situation to deviate from the ideal.

Calculated values for annual depreciation costs will obviously depend on the estimate of the initial value of an investment, as discussed in the beginning of this section. They will also depend on the estimated useful life of an investment. The longer the useful life, the lower the annual depreciation costs.

It is an unfortunate fact, however, that textbook estimates of useful life are often used in project analysis without regard for what is known of previous evidence about an investment's actual life, or for prevailing conditions which are likely to affect the length of life of the proposed investment. The actual length of estimates of useful life for water system improvements, for instance, is directly related to the amount and quality of maintenance they receive after they become operational. Because of heavy demands for funds to be used for defense and social programs in Egypt during the recent past, however, relatively few funds were available for the maintenance of irrigation works. As a result, the productivity of irrigation works has decreased fairly rapidly, and the useful life of many investments in this area has been far less than the standard values attributed to such investments in standard references. The relation between project maintenance and project depreciation is one of the many variables which should be considered when analyzing new projects for improving Egypt's water delivery system, and estimates of an investment's actual life will have to be weighted to account for such variables.

The calculated annual opportunity cost for capital invested in a project will depend on the estimated value of the investment, on the procedure used to calculate the annual depreciation costs, and on the rate used to calculate the opportunity cost for capital. In standard benefit/cost analysis and in the partial budgets outlines in this report, the opportunity cost is calculated in terms of an interest rate. The problems involved in imposing a standard interest rate to cover capital costs in a Muslim society have already been discussed above (Section I. B), and it is unlikely that they will be resolved in any definitive way in the near future. It is most important, therefore, that analysts develop good estimates of the investment costs to be used in the calculation of the annual opportunity cost of the capital invested in a project. Only then can they conduct a sensitivity analysis (see IV. B) to estimate the probably impact of other methods of assessing opportunity costs on the project's feasibility.

2. Average Annual Benefits and Costs

The type of partial-budget analysis advocated in this report is based on the use of average annual benefits and costs. As pointed out above, this is one of the more common methods for determining net present value for the purposes of benefit/cost analysis (see Appendix B). For projects designed to improve Egypt's water delivery system, it is probably not possible to obtain good estimates for a sequence of annual benefits and costs, and virtually impossible to obtain even reasonable estimates extending over the life of a project.

If good estimates of investment costs could be made and methods agreed upon for calculating the annual depreciation costs and capital opportunity costs, the process would eventually generate good estimates of many standard operations (e.g. cost per mesqa turn out, cost per m^3 of earth used to raise mesqas and branch canals, etc.). For making partial budget analyses of Egyptian water management projects at this time, however, it was necessary to rely on estimates of average annual depreciation and capital opportunity costs.

3. Learning to Use New Farming Systems and the Time of Occurrence of Benefits and Costs

In this report, the average amount of benefits and costs estimated for each possible alteration in a water system are assumed to occur as soon as the system is changed. In most cases, however, the average annual benefits and costs will not occur until there are also changes in the farming techniques used on the irrigated area. Such changes do not usually occur immediately. Farmers require time to learn how to shift from their old farming system to the new system made possible by an irrigation improvement project.

For example, a shift from the use of tamburs and saqias to a well-designed gravity-flow system requires that farmers learn new ways to handle irrigation at the field level. After the improvements are in effect, there will always be some farmers who fail to realize that the increased head available allows them to shift from the small basins which were required under the old system to long furrows or large basins. Under the new system, farmers should be able to irrigate larger areas in less time and with less labor, but as long as they fail to use the water in the new way, they will fail to realize much benefit from the irrigation improvements.

When old farming systems are replaced by new, there will always be a lag between the potential and the actual. This has two important implications for the economic analysis of proposed changes in a water delivery system. First, it may result in an over-statement of the implicit present value of both anticipated costs and anticipated benefits. This would, of course, skew the results of the partial-budget analysis. Secondly, and perhaps more importantly from a policy standpoint, the recognition of such a lag suggests that appropriate extension education should be provided to teach farmers the appropriate new techniques. For the economist, one of the important variables for determining the present value of anticipated benefits and costs should be the type of educational programs which exist to help shorten the period of disjunction between the existence of improvements in the irrigation system and their actual adoption and use.

III. AN EXAMPLE OF PARTIAL-BUDGET ANALYSIS IN ACTION: MESQA 26, ABUEHA

Mesqa 26 on Abueha Canal is located south of the city of El Minya on the EWUP pilot project site. This mesqa is a small watercourse which previously served 40.3 feddans and now serves 39.6 feddans. (A feddan is 1.038 acres.) Until January, 1981 the mesqa was typical of many of the mesqas in the area. There was a trail on each side of the mesqa. Its cross section had deteriorated from the designed cross section and varied greatly along its length. The normal pattern of irrigation on this mesqa prior to January, 1981 appears in Table 1. Table 2 gives the crop rotation pattern and gross profits for the area.

In January, 1981, the mesqa was raised so that land served by Mesqa 26 could be irrigated by gravity flow with a head of at least 20 cm. At the present time water is pumped into the head of the mesqa from the Abueha Canal. It is anticipated that the Abueha Canal will eventually be raised as well, and preliminary studies indicate that when raised it should have no difficulty in generating a water level in Mesqa 26 at least equal to that which is now obtained through the pumping system.

An analysis of this type should consist of more than the simple adding up of benefits and subtracting of costs for a proposed change in a system. Many, if not most, of the items listed on the worksheets cannot be assessed with complete certainty, for certainty exists only when data are collected after the fact. The results of a change which has already taken place are certainly of interest, but the real value of a partial budget is as a tool, based on the analysts' current knowledge of the situation, for estimating probable consequences of a proposed change. If the partial budget is to be sound, analysts must make sure that their decisions are timely, and that they have considered all of the significant issues. Engineers, agronomists, soil scientists, sociologists and economists must provide their best possible estimate of the expected consequences of the proposed change. If the partial budget is to be sound, analysts must make sure that their decisions are timely, and that they have considered all of the significant issues. Engineers, agronomists, soil scientists, sociologists and economists must provide their best possible estimate of the expected consequences of the proposed change.

Table 1. Irrigation on *Mesqa* 26, Abueha Canal.

Method of Irrigation	Right Side feddans	Left Side feddans	Total feddans
Lifting (by *tambour*)[a]	5.8	9.4	15.2
Lifting and Gravity	1.7	3.3	5.0
Gravity	7.0	13.1	20.1

[a] The *tambour* is the Egyptian term for the Archimedes' screw. Costs for irrigating by *tambour*, with an average of 15 irrigations per year, are L.E. 3.4 per feddan for each irrigation or L.E. 51.00 per feddan per year.

Table 2. Rotation and Gross Profit per *Feddan*, 1980/81.

Crop	*Feddans*	Gross Profit/*Feddan*[b] L.E.
Birsim (clover) - Short Season	8.0[a]	67.00
Broadbeans	12.8	149.50
Cotton	20.8	90.54
Berseem - Long Season	5.3	192.00
Broadbeans - Long Season	3.7	149.50
Wheat	10.5	127.53
Maize	19.5	79.40
		109.34[c]

[a] Includes 2.5 *feddans* of tomatoes grown on this *mesqa* in 1980. Tomatoes are not usual in this area and are therefore not included in the rotation presented in Table 2.

[b] Taken from Cost Enterprise Crop Studies done for the Abouha area.

[c] The area is doubled cropped and the weighed average annual gross profit per *feddan* is therefore L.E. 218.68. See Note 1, Worksheet.

In cases where definitive information is not available, the team can offer alternative evaluations and give a range of likely outcomes. The technique of estimating values for variables which are uncertain is called "sensitivity analysis," and it was used in the case of Mesqa 26, described below.

A. Partial Budget for the Raising of Mesqa 26

Part 1. Specification

The purpose of this analysis is to estimate the benefits and costs associated with raising of Mesqa 26. After the raising of the mesqa, the 39.6 feddans of land served by this watercourse can be irrigated by gravity flow irrigation with a head of at least 20 cm. Raising the mesqa involved the loss of land, i.e., .6 feddans, from the net irrigated area. The cost of raising the 840 meter mesqa was estimated to be L.E. 5,500. To evaluate the consequences of raising the mesqa, it will be compared to the performance of the same mesqa as it operated prior to January, 1981. Farm level benefits and costs are estimated using farm level values. Government costs are included at estimated bid costs.

Part 2. Changes in the System

The cost to the farmers of lifting water to the fields will decrease as the result of the changes on Mesqa 26. Based on previous EWUP experience with improved irrigation, it is reasonable to expect both a at least modest yield increase and a decrease in the required irrigation labor. The interrelationship between depreciation and maintenance costs needs to be given careful consideration, since depreciation can be very rapid if the maintenance work is not adequate. The other items to be considered are presented in the worksheets below.

Part 3. Estimated Benefits and Costs

Estimates are presented in the following worksheets for two sets of assumptions about the possible consequences of raising Mesqa 26: (a) no yield increase and high (L.E. 25.00/feddan) pumping costs and (b) a 5% yield increase and low pumping costs (L.E. 4.63/feddan) which is based on a very rough estimate of the cost of raising Abueha Canal.

B. SAMPLE WORKSHEETS

Evaluation of Water Distribution Projects

Date February, 1981

Basis for Comparison: Meska 26 before elevation.

Proposed Change: Elevate Mesqa 26 -- convert to gravity.

Alternative Assumptions: (a) No yield increase and high pumping costs and (b) 5% yield increase and low pumping cost.

	(a)	(b)
I. Benefits		
A. Average Annual Added Benefits		
1. Increased gross profit from potential yield increases	0.00	L.E. 788.04
(b) See Note 1		
2. Increased gross profits from shifts to higher valued crops		
3. Value of water conserved		
4. Annual value of land saved		
5. Other		
Total Average Annual Added Returns	0.00	L.E. 788.04

	(a)	(b)
B. Average Annual Reduced Costs		
1. Pumping Savings on 15.2 *fd* plus 1/2 of 5.00 *fd* (see Table 1) at cost of L.E. 51.00/*fd*	L.E. 902.70	L.E. 902.70
2. *Mesqa* maintenance 10 m/day/man 84 man days @	L.E. 84.00	L.E. 84.00
3. Drain maintenance	0.00	0.00
4. Labor for irrigation 15 irrigations cost L.E. 1.00/*fd*/irrigation job time cut by 1/3 (39.6 *fd*) x (L.E. 5.00)= L.E. 198.00	L.E. 198.60	L.E. 198.60
5. Transportation	0.00	0.00
6. Other	0.00	0.00
Total Average Annual Reduced Costs	L.E. 1184.70	L.E. 1184.70
Average Annual Total Benefits = Total Average Annual Reduced Costs + Total Averaged Annual Added Revenue	L.E. 1184.70	L.E. 1972.74

II. Costs

C. Average Annual Added Costs

	(a)	(b)
1. Average annual depreciation	L.E. 183.33	L.E. 183.33
L.E. 5,500/30 yr. = 183.33 (See Note 2)		
a. Earth work ____________		
b. Gates and control ____________		
c. Structures ____________		
d. Other equipment ____________		
e. Other ____________		
2. Maintenance	L.E. 126.00	L.E. 126.00
1.5 x previous maintenance cost (L.E. 84.00) x (1.5) = 126.00		
a. Earth work ____________		
b. Gates and control ____________		
c. Structures ____________		
d. Other equipment ____________		
e. Other ____________		

		(a)	(b)
3.	Interest on average investment	L.E. 110.00	L.E. 110.00
	$\frac{5,500}{2} \times .04 =$ L.E. 110.00		
	a. Construction ______		
	b. Equipment ______		
	c. Other ______		
4.	Annual operating costs	______	______
	a. Equipment ______		
	b. System operation and maintenance ______		
	c. Other ______		
5.	Pumping costs	L.E. 990.00	L.E. 183.74
	(a) (L.E. 25.00) x (39.6 fd) = 990.00		
	(b) Raise Abucha - see Note 2		
	a. Fixed costs ______		
	b. Operating costs ______		
	c. Other costs ______		
6.	Other costs	______	______
	Average Annual Total Added Costs	L.E. 1,409.33	L.E. 603.07

	(a)	(b)
D. Average Annual Reduced Benefits		
1. Annual value of land lost	L.E. 130.20	L.E. 130.20
See Note 3		
2. Other		
Total Average Annual Reduced Benefits	L.E. 130.20	L.E. 130.20
Added Costs + Reduced Benefits	L.E. 1539.53	L.E. 733.27

Net Benefits (Costs)
(A + B) - (C + D)
(a) + (L.E. 1184.70) - (L.E. 1539.53) = -L.E. 354.83

(b) + (L.E. 1972.74) - (L.E. 733.27) = + L.E. 1239.47

Comments:

PART III - C

NOTES -- WORKSHEETS FOR *MESQA* 26

NOTE 1: The initial yields, gross revenues and variable costs per *feddan* for the crops on *Mesqa* 26 (Abucha Enterprise Cost Studies) are:

Crop	*Feddan* (1979-80 crop year)	Yields	Gross Revenue L.E./*Fd*	Variable Cost L.E./*Fd*
Wheat	10.5	10 *ardab**	210.00	82.47
Beans	16.5	6.5 *ardab*	244.50	95.00
Berseem (clover) (short season)	8.0	2 cuts	88.00	21.00
Berseem (long season	5.3	5 cuts	233.00	41.00
Maize	19.5	8 *ardab*	158.00	78.60
Cotton	20.8	6 *kantar***	229.50	138.96
Weighted Avg.			199.41	90.07

* 1 *ardab* = 198 liters = 5.62 bushels (U.S.)
** 1 metric kantar of cotton (unginned) = 157.5 kg. To convert to tons/ha multiply by .3749.

The initial area served by *Mesqa* 26 was 40.2 *feddans*, which were double-cropped, giving 80.4 productive *feddans*. The area currently under cultivation is 39.6 *feddans*, also double-cropped, or 79.2 crop-producing *feddans*. Current gross revenue should be:

79.2 *feddans* x L.E. 199.41 = L.E. 15,793.27

Total variable costs should be:

79.2 *feddans* x L.E. 90.07 = L.E. 7.133.54

If yield increase 5%, average gross revenue will increase from L.E. 199.41 to L.E. 209.38, and average gross profit will increase L.E. 9.97 per *feddan* per year. Since the land is double cropped, the increase in gross profits per *feddan* per year would be L.E. 19.94, or 789.66 for 39.6 *feddans* (the area served by *Mesqa* 26).

NOTE 2:

A preliminary rough estimate of the volume of fill needed to raise the 4 km of Abueha Canal to a level needed to obtain 20 cm of head was 25,000 m^3. The cost of fill on *Mesqa* 26 was L.E. 1.60 per m^3. These costs accounted for about 40% of the total cost of Mesqa 26. If the total cost (including structures) averaged L.E. 4.00 per m^3 for Abueha, the cost of raising the canal would be L.E. 100,000. At a 30 year life, annual depreciation would be L.E. 3,333 and average annual interest costs would be L.E. 2,000 (L.E. 100,000/2) x (.04). The average annual costs for each of the 1,150 *feddan* under Abueha would be L.E. 4.64, (L.E. 5,336)/(1,150 *feddans*). The cost for the 39.6 *feddans* under *Mesqa* 26 would be L.E. 183.74. This is a very rough estimate of the average annual cost of lifting water by raising Abueha Canal. This estimate should be made more carefully. Its value is a key factor in the outcome of the evaluation.

NOTE 3

The weighted average gross profit per *feddan* (gross revenue per *feddan* less total variable cost per *feddan*) was L.E. 218.68 for *Mesqa* 26 (see Note 1). The loss of .6 *feddan* as the result of widening *Mesqa* 26 would, therefore, cause weighted average gross loss in profits of L.E. 131.22 per year.

Mesqa 26 lies within the boundary for MOI* land, but .6 *feddan* of land which had been cropped previously had to be sacrificed. This means that farmers were farming MOI land, a widespread practice. Production lost, however, is production lost, regardless of the technical ownership of the land involved.

Another method for determining the annual value of the .6 *feddan* of land taken out of production would be to determine the sale value of land and multiply that value by the appropriate interest rate. For example, if land has a value of L.E. 3,000 per *feddan* and the appropriate interest rate is 10%, then the annual value of the .6 feddan taken out of production would be (L.E. 3,000) x (.6) x (.10) = L.E. 180. If earnings from land are expected to increase in the future, then the value of land lost times the interest rate will tend to be greater than the loss in terms of current gross profit lost.

* Ministry of the Irrigation, making it, strictly speaking, government land.

D. Interpretation of the Benefit/Cost Analysis for Mesqa 26

Under set (a) assumptions (no yield increase and high pumping costs prior to January, 1981, the average annual net **loss** is estimated to be L.E. 354.83. This would seem to indicate that the project is not economically feasible. If, however, gross profits along the entire reach of Mesqa 26 were increased by L.E. 354.83, the irrigation project would break even. Assuming that both the prices received for all crops, and the variable costs, remained the same as previously calculated, a 3.0% increase in yield would generate the necessary increase in gross profits.[1] Previous EWUP experience indicates that it is reasonable to expec. . yield increase at least this great, provided that farmers understand how to take advantage of the improved irrigation system and that the proposed Farmer Organization provides enough discipline to maintain the farm irrigation schedule.

---

[1] Let GP_1 be initial gross profits, GP_2 the new level of gross profits, TR_1 be initial gross revenue, TR_2 be the new level of gross revenue, TVC the total variable costs, L=1+R where R is the rate of increase in yields and S=1+K where K is the rate of increase in gross profits. If P_i equals the price, Fd_i the feddans and Yd_i the yield for the ith crop, then $TR = \Sigma(P_i Yd_i Fd_i)$. The relation between $GP_1 = (TR_1 - TVC)$ and $GP_2 = (TR_2 - TVC)$ in terms of yield increase is shown by (1). The

$$(1)\quad GP_2 = (TR_1)(L) - TR_2 - TVC$$

relationship between GP_1 and GP_2 in terms of changes in gross profits (S = 1 + K) is shown by (2) below. Therefore, the relationship between

$$(2)\quad GP_2 = GP_1 + (K)(GP_1) = (TR_1 - TVC) + (K)(TR_1 - TVC)$$

changes in GP (represented by S = 1 + K) and yield changes (L = 1 + R) is shown by (3) and (4).

$$(3)\quad GP_2 = (TR_1)(L) - TVC = (TR_1 - TVC) + (K)(TR_1 - TVC)$$

$$(4)\quad L = \frac{TR_1 + (K)(TR_1) - (K)(TVC)}{TR_1} = 1 + K - K\frac{TVC}{TR_1}$$

If TR_1 = L.E. 15,793.27 and TVC = L.E. 7,116, then $(K)(GP_1)$ = K(15,793.27 − 7,133.54) = 354.83 (the initial deficit in gross profit) therefore, $K = \frac{354.83}{8659.73} = .04 \quad .04$

Since $L = 1 + K - K\frac{TVC}{TR_1}$; $L = 1. + .04 - .09\left(\frac{7,133.54}{15,793.27}\right)$

$= 1 + .04 - (.04)(.45) = 1 + .018 = 1.02 = 1 + R$

and R = .03 or a 3.0% increase in yields is required to produce a L.E. 354.83 increase in gross profits.

Another crucial variable that needs to be examined in greater detail is the relationship between depreciation and maintenance. If Farmer Organizations fail to provide organizational strength, depreciation and maintenance costs could be significantly higher than as estimated in the partial budget given above. A good maintenance program could decrease depreciation costs, but poor maintenance programs cause depreciation costs to increase sharply.

The average annual net benefits using the (b) set of assumptions (a 5% yield increase and low water lifting costs after January, 1981) are estimated to be L.E. 1239.47. Using a 40.2 feddan land base, this amounts to a net benefit of L.E. 30.83 per feddan. If these results could be realized in all of the 1150 feddans under the Abueha Canal, the farmers in this village would realize an increase in net income of about L.E. 35,500 per year, which is a sizable increase. If the benefits and costs were calculated using economic values (input and output prices at value to the nation), the net benefits would be even greater.

The use of partial budgeting does not eliminate the need to use judgment in reaching a decision about the desirability of a project, but it does permit analysts to do three things: First, it improves their chances of correctly predicting the outcome of a project. In the case of Mesqa 26, the raised mesqa does indeed seem superior to the ordinary mesqa which it replaced. Second, it gives analysts a tool for appraising the relative quality and importance of different information and data. In the case of Mesqa 26, it seems apparent that the outcome of the evaluation will depend to a considerable extent on the estimates of the changes in yields and in the cost of lifting water into the raised mesqa. Third, the preliminary evaluation should give analysts a better idea of the relative merits of different alternatives for change. After the preliminary evaluation has been completed, the team of analysts should be able to answer the following questions:

1. Based on the preliminary evaluation, does the proposed change seem to be desirable?
2. Which portion of the available data seems to be reliable, and which is significant if the irrigation project is to be successful? (The answer to this question will, of course, also indicate which information is not reliable, and where analysts will require better estimates on which to base their decisions.
3. Which modifications of proposed changes would be likely to result in superior alternatives?

In answering the last two questions, the team of analysts will probably go through several cycles of evaluation for each proposed irrigation project. This is a highly desirable process, likely to result in sound analyses of projected programs. Still, evaluations must stop at some point and decisions be taken. The team of analysts can impose their own deadline, or they may have to accept one imposed by outside decision-makers.

IV. Extending the Results: The Many Faces of the Feasibility Study

A. Project Analysis as a Continuing Activity

In outlining the method for conducting feasibility studies, we have tried to show that they are a tool designed to help decision-makers in evaluating potential projects. To be of the most benefit, project analysis should begin at an early stage in the proceedings, for then it can serve decision-makers in a variety of ways.

It is first necessary to define the exact nature and extent of the problem which a proposed project will solve. A prefeasibility analysis will help the decision-maker to define the limits of the problem, and to pick out those areas which are open to beneficial change.

After the decision-maker has specified the problem, and he has narrowed the list of possible solutions under consideration to a reasonable number, the feasibility study comes into play once again. The analyst is able to evaluate each possibility through the results of its individual analysis. This is the final preconstruction phase, and each of the candidates analyses in detail should be considered real possibilities for implementation.

When continued into the construction phase, the analysis serves as a basis for monitoring construction performance and determines the impact of new information gained during construction. It may, for instance, be necessary to modify the original design in the light of this new information.

The final stage of analysis—and the most difficult test for a project-- takes place after construction is completed and the project is in operation. At this point what have hitherto been expected benefits and costs become benefits and costs in fact. Peter Drucker (5, p. 68) states, "... there are few better tests of the competence and performance of a management than its performance in appropriating capital and the actual results of capital investment decisions measured against expectations." Drucker also points out that this is rarely done in practice, but that, in those cases where such comparisons are made, they yield handsome dividends.

Almost all applied programs for project analysis have been developed along the lines of repeated and continuing analysis described above. The U.S. Department of Agriculture course, "Agricultural Capital Project Analysis," suggests the use of a five-stage process:

1. prefeasibility studies
2. feasibility studies
3. ex-ante evaluation
4. construction performance
5. expert evaluation

The World Bank, the U. N. Development Program, the U. S. Bureau of Reclamation, and private consulting firms all use similar procedures for evaluating projects, though terminology and the definition of the various stages differ.

The present report does not argue for any one type of procedure, for clearly, no one has yet developed a process of evaluation which is markedly superior in all situations. Yet one thing is certain: any procedure must involve continuing analysis, with several distinct stages to the process. The authors of this report strongly recommend that decision-makers agree upon a series of procedures of the type outlined above before the project analysis begins. If, on the otherhand, the project is already in progress the important thing is to begin project analysis at whatever stage the analysts find it.

B. Sensitivity Analysis

Sensitivity analysis is the systematic exploration of the way in which changes in the value of specific variable affect other variables and change the outcome of the analysis. Sensitivity analysis is particularly useful in cases where the value of some of the variables cannot be estimated with a high degree of reliability, and where alternative strategies generate different value for the variables. Hessa 26 is used to illustrate sensitivity analysis and should serve as a model for the use of sensitivity analysis.

It was mentioned earlier that two of the important variables in the evaluation of Mesqa 26 were the changes in yields and the costs of lifting water into the elevated Mesqa. Refer to the worksheets for Mesqa 26 for the (a) set of assumptions used here. Based on the partial budget format: A is the average annual benefits (increase in gross profits) associated with yield increases; B is the average annual reduced costs (B = L.E. 1184.70); C is the average annual added costs where C = L.C. + O.C. (C = L.E. 1409.33) and O.C., the other added costs, are L.E. 419.33. L.C. is the cost of lifting water into the elevated mesqa; and D is the average annual reduced returns, L.E. 130.20.

To compare benefits and costs, we use the equation:

$$A + B = C + D$$

Using the values given above,

A (increase in gross profits) + L.E. 1184.70 (reduced cost - B) = L.C. (water lifting cost) + L.E. 419.33 (other added costs) + L.E. 130.20 (decreased returns - D)

A + L.E. 1184.70 = L.C. + L.E. 549.53

L.C. = (L.E. 1184.70 - L.E. 549.53) + A = L.E. 635.17 + A

This means that the cost of lifting water into the Mesqa (L.C.) must be no more than equal to the increase in gross profit (A) plus L.E. 631.15.

Using a 39.6 feddan base,

L.C./fd = A/39.6 + L.E. 635.17/39.6 = A/fd + L.E. 16.04

A/fd is the required increase in gross profits per feddan which would be necessary to offset the increased cost of lifting water into the mesqa for one feddan. The initial average gross profits per feddan were L.E. 218.68 (see Note 3, Worksheet). Therefore

A/fd = K (L.E. 218.68)

where K is the required rate of increase in gross profits (see footnote 1). Since L = 1 + R, where R is the required increase in yields, R and K are related as follows:

$$R = K - K(TVC/TR) = K - K(90.07/199.41)$$

$$R = K - K(.45) = K(1-.45) = .55K$$

$$K = R/.55$$

Therefore

$$L.C./\underline{Ed} = 16.04 + K(218.68) = 16.04 + \underline{R}(218.68) = 16.04 + R(396.60)$$

$$\text{or } L.C./\underline{Ed} = 16.04 + R(396.60)$$

The following graph shows this same relationship:

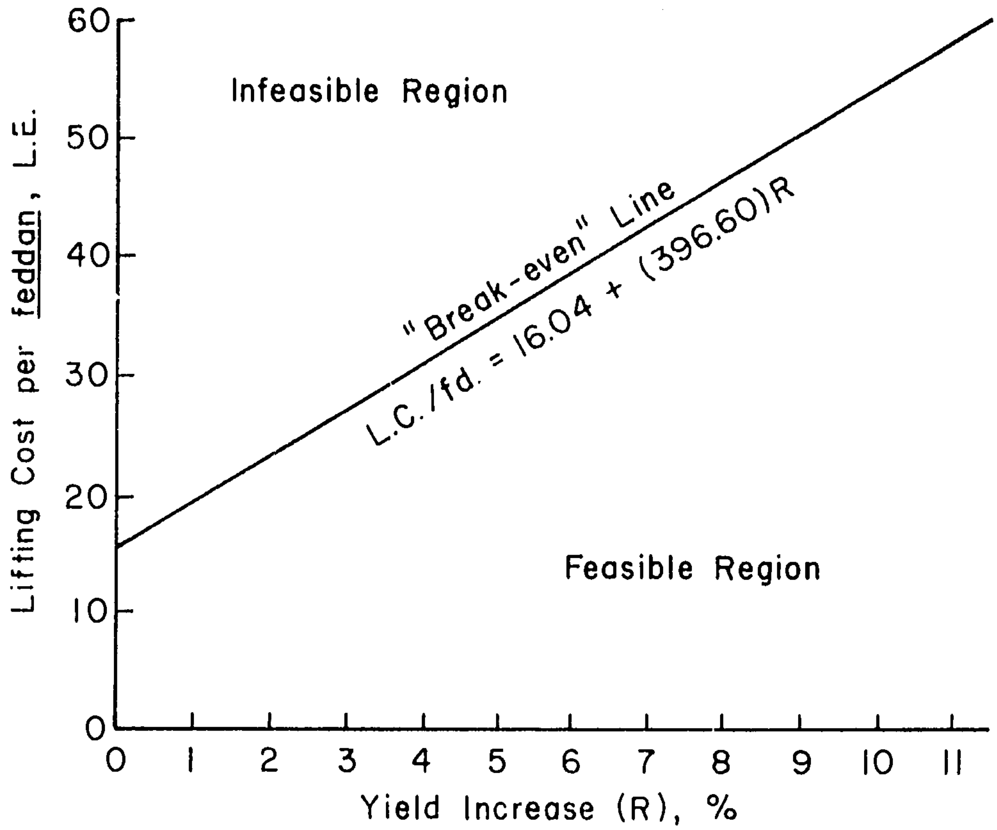


Figure 1. "Break-even" percentage of yield increase necessary to offset lifting cost per *feddan*.

The most useful aspect of Figure 1 is not the Break-even Line, n arrived at by pairing specific values for lifting cost (L.C./Ld) percent yield increases, but rather the regions which surround the line. For example, the team of analysts might reach the conclusion that lifting costs will be low and the expected yield increase such that the paired values fall well within the Feasible Region. Ideally, it would be nice to have precise values for variables such as pumping costs and expected yield increases, but if the proposed changes in the farming system have never been done before, such precise estimates are impossible to obtain.

In such cases, one alternative is to postpone decisions. Unfortunately, a country with a growing population and an ever increasing need for food cannot afford this luxury. Decisions have to be made, not postponed.

If the decisions are to be the best possible, professionals will be required to use their knowledge to make estimates of expected values for variables such as pumping costs and yield increases. Then these estimates can be related to the decision criterion (such as the Net Present Value Criterion discussed, pp. 3-4) and to other variables. This has been done in the sensitivity analysis presented in Figure 1. High levels of precision in the estimates may not be necessary. If the paired values fall either on or close to the Break-even Line, additional fact-finding may be required before a decision is made. However, if the expected values result in paired values which are a long way from the Break-even Line, a decision using rough estimates may be possible.

If National economic prices rather than on-farm prices were used to calculate the Break-even Line, which would be the appropriate set of prices to use for analysis at the national level, the calculated Break-even Line would be above the line presented in Figure 1, that is, the changes would be economically feasible as long as prices paid for inputs increased less than prices received for agricultural products. This means that the Feasible Region is larger at the national level than at the farm level and higher pumping costs per feddan and lower yield increases would be acceptable at the national level than at the farm level.

It is often necessary to make decisions with imperfect information, and this is especially the case with regard to investing capital in improvements of irrigation systems. The goal should be to make decisions based on the best information and professional judgments available at the time. Although better information would, of course, be valuable, delays in reaching decisions can be costly enough to offset its utility. Net benefits delayed are, in fact, missed opportunities.

C. Alternative Designs

Analysts should develop several possible solutions to a single problem, then pick the one that best suits the particular situation. On Mesqa 26, for instance, the systems for water delivery canals, access roads to fields, and drains were all linked together. Traditionally, field access roads run along side a mesqa and are only large enough for animal traffic. Furthermore, no provision is made for drainage in the traditional model but small, single-farm ditches, or marwas, which run parallel to the raised mesqa also provide limited surface drainage.

Given such a situation designers have two choices. The first is to keep the present system of access roads on the banks of the mesqa, though the roads take up considerable space, and once in place, they would be costly to modify them enough to accommodate modern machinery. Any such modifications would also necessitate a certain loss of land presently under cultivation, and would probably be unpopular with the farmers.

A second alternative would be to extend the fields to the very border of the raised *mesqa*, and to irrigate them through the use of siphon tubes. A road and drainage canal could then be placed midway between two *mesqas*, to serve fields on either side which would be irrigated by both *mesqas*. In this second model, field access roads would be separate from watercourses, and both systems could be modified more easily and less expensively in the future. *Mesqas* of this type could also be maintained more easily mechanically. Although definitely the more attractive alternative on the surface, however, the analysts should bear in mind that this second solution would require a significant change in farming practices, and a degree of sophistication in the use of machinery. For such modifications to be successful, farmers would have to be willing and able to cooperate.

The two alternatives described above are just one example of the kind of multiple solutions which decision-makers must weigh if they are to arrive at the best possible irrigation projects for the nation.

V. Summary and Conclusions

This report contains a set of procedures which can be used to analyze proposed changes in the water distribution system in Egypt today. The authors have recommended the use of partial-budget analysis, largely because data necessary for more detailed analysis is not presently available. The report also discusses the relationship between partial-budget analysis and net present value analysis, and shows under what conditions the two methods will rank alternative irrigation projects in the same order.

The authors offer a set of partial budget worksheets as a guide to use to evaluate proposed changes. Both the worksheets and the partial-budget analysis are used to analyze the raising of a mesqa located in Upper Egypt near El Minya. This case study and the information put forth in this report are guides for the reader's own project analysis. Further extension of the method, that is, post-analysis, can also serve as a basis for innovation in design and the identification of important gaps in the available data.

Feasibility studies should not be merely irksome, bureaucratic requirements which must be satisfied, but rather a vital and necessary part of all decision making. It is the authors' hope that the methods outlined here will serve experts from all disciplines concerned with improving Egypt's water delivery system, and will be the basis for leading them to decisions in the best interest of the farmers and the nation.

Appendix A

SAMPLE WORKSHEETS

Evaluation of Water Distribution Projects

Date_______________________

Basis for Comparison:____

Proposed Change:____

Alternative Assumptions:____

____

____

I. Benefits

A. Average Annual Added Benefits

1. Increased gross profit from ________________________________ potential yield increases

2. Increased gross profits from ________________________________ shifts to higher valued crops

3. Value of water conserved___________________________________

4. Annual value of land saved__________________________________

5. Other____

Total Average Annual Added Returns ______________________________

B. Average Annual Reduced Costs

1. Pumping ________________________

2. Mesqa maintenance ________________________

3. Drain maintenance ________________________

4. Labor for irrigation ________________________

5. Transportation ________________________

6. Other ________________________

Total Average Annual Reduced Costs________________________

Average Annual Total Benefits =

Total Average Annual Reduced Costs +

Total Averaged Annual Added Revenue________________________

II. Costs

C. Average Annual Added Costs

1. Average annual depreciation ____________________

a. Earth work ________________

b. Gates and control________________

c. Structures ________________

d. Other equipment ________________

e. Other ________________

2. Maintenance ____________________

a. Earth work ____________________

b. Gates and control____________________

c. Structures ____________________

d. Other equipment ____________________

e. Other ____________________

3. Interest on average investment ______________

   a. Construction ______________

   b. Equipment ______________

   c. Other ______________

4. Annual operating costs ______________

   a. Equipment ______________

   b. System operation and maintenance ______________

   c. Other ______________

5. Pumping costs ______________

   a. Fixed costs ______________

   b. Operating costs ______________

   c. Other costs ______________

6. Other costs ______________

Average Annual Total Added Costs ______________

D. Average Annual Reduced Benefits

1. Annual value of land lost ____________________

2. Other ____________________

Total Average Annual Reduced Benefits ____________________

Added Costs + Reduced Benefits ____________________

Net Benefits (Costs) ____________________

Comments:

Appendix B

THE USEFULNESS OF COMPARISONS OF AVERAGE ANNUAL BENEFITS AND COSTS AND NET PRESENT VALUES

Sassone and Schaffer [3, Chapter 2] point out that the Present Value Criterion is usually the proper criterion to use in benefit-cost analysis. The formula for net present value is:

$$NPV = \frac{B_0 - C_0}{(1+d)^0} + \frac{B_1 - C_1}{(1+d)^1} + \ldots + \frac{B_n - C_n}{(1+d)^n}$$

C_t = the value of costs incurred in a time interval

t = the time interval

B_t = the value of benefits incurred in time interval "t"

d = the discount rate

n = the life of the project in years

If the benefits and costs received were the same for each of the "n" years, the formula could be expressed as:

$$NPV = \sum_{t=0}^{n} \frac{(B - C)}{(1+d)^t} = \frac{(\overline{B} - \overline{C})}{(1+d)^t} = (\overline{B}-\overline{C}) \left(\frac{1 - (1+d)}{d}\right)^{-n}$$

where $\frac{[1 - (1 + d)^{-n}]}{d}$ = the expression for calculating the present value of a simple annuity (i.e., the "coefficient for present value")

$(\overline{B}-\overline{C})$ = payments at the end of each year

d = discount rate

n = number of years that $(\overline{B}-\overline{C})$ are generated.

The coefficient for present value can be found in standard tables or the present value can be determined using a calculator programmed to perform standard financial calculations.

If a series of alternative water projects are ranked from most favorable to least favorable (assuming the distribution of benefits and costs described above and with equal life spans), ranking on the basis of either *net present value* or *average annual benefits and costs* will give the same result.

Since the pilot irrigation projects considered here will have equivalent lifespans, and since too little empirical information is available to construct reliable time schedules of benefits and costs, it was decided to use *average annual benefits and costs* as the decision-making criterion. Average annual benefits and costs are flows which occur each year, and are generally easier to understand than the (usually large) stock value of the net present value of such a flow. Average annual values are particularly easy to understand when they are expressed in terms of either net benefits per farmer or per *feddan*.

If, on the otherhand, the projects to be compared are of significantly different lifespans, annual benefits and costs (or net benefits) should be converted to *net present value*, using either the formula stated above or a business calculator. Assume, for example, that an elevated, earth *mesqa* would generate estimated average annual net benefits of L.E. 350 and would have an estimated lifespan of fifty years. The alternative project, a sprinkler system, would generate an estimated average annual net benefit of L.E. 400 but would last only 25 years. Comparison of the average annual net benefits alone would suggest that the sprinkler system was the most desirable pilot project. Yet the present value of twenty-five years of net benefits from the sprinkler system (at a 6% interest rate) would be L.E. 5,420.14, while that from the fifty years of net benefits from the elevated earth *mesqa* would be L.E. 5,847.65. Obviously in this case, net present value is the preferred decision-making criterion, for it takes into account the different lifespans of the two potential projects. With projects of different lengths, it is not recommend to use average annual net benefits and costs as the decision-making criterion.

In the case where sound empirical evidence exists as a basis for establishing time schedules for benefits and costs for each year, and it emerges from this that the occurrence in time of either benefits or costs is significantly different for the different alternatives, analysts should use the first discounting formula presented in this Appendix to compare the alternatives.

Appendix C

DEPRECIATION AND INTEREST COSTS

There are many ways to calculate depreciation costs: straight-line depreciation, amortization, declining balance, sum-of-the years digits, sinking-fund and the list goes on. No single one of these methods of calculating depreciation is the correct method, and the best method to use will depend on the particular case. The issue is further complicated by the nearly universal impact of inflation. The legitimate purpose for calculating depreciation costs is to account for the decrease in the value of an investment which occurs through use. If the value of an investment is increasing in nominal dollar terms because of inflation, the issue is further complicated. The sinking-fund method is designed to set up a special fund for the replacement of an investment when replacement is required. It is particularly important to compensate for inflation when the sinking-fund method is used.

The straight-line method of depreciation was selected for use in the evaluation of the sample pilot project in this report. The straight-line method of calculating depreciation costs is undoubtedly that most generally used to calculate depreciation costs in feasibility studies. The method is easy to understand and the calculations are easy to perform. Yearly depreciation costs:

$$DEP = \frac{C - S}{n}$$

where DEP is yearly depreciation costs, C is the initial cost, S the salvage value and n the useful lifespan.

When straight-line depreciation is used, interest costs are usually calculated on an average annual basis using the average value of investment:

$$INT = \left(\frac{C - S}{2} + S\right) (d)$$

where INT is average annual interest cost, and d the interest rate used. S is the salvage value and the associated interest charges occur each year. (C-S) is that portion of the investment which is depreciated and its average value during the lifespan of the investment is one half (C-S). The actual interest charges during the initial years of the lifespan are greater than the average interest charge, and the interest charges in the later years of the lifespan are less than the average interest charge.

The interest costs calculated for each year will be based on the undepreciated value of the investment for that year. Therefore, the total interest charges made against an investment will depend on the depreciation method used. Using straight-line depreciation as the base method, compare it with two other common methods of calculating depreciation costs: accelerated depreciation (e.g., declining balance) and decelerated depreciation (e.g., amortization). These are shown in Table C-1 and Figure C-1. Assume that the investment has no salvage value, has an interest rate of 8% and that the investment will have a useful lifespan of five years.

The differences in the total interest and depreciation costs in this example for the three methods of calculating depreciation costs are not great (see Table C-1). The differences which do exist are due to the differences in interest costs. Interest costs are greatest for the amortization method because the nondepreciation value of the investment.

Obviously, in real life situations, not all parts of an investment will depreciate at the same rate. Earth works, for example, may depreciate over a period of thirty years, gates and controls over a period of ten years, and accompanying structures over a period of fifteen. The calculation of depreciation values for this investment would require a more complicated partitioning of the value involved than that presented here.

Unless sound, empirical information exists for these varying rates of deterioration, however, such elaborate calculations are not practical. Present day Egypt does not have sufficient sound data to warrant such calculations, and the results would be questionable. It is more important at this time, rather, to stress the relationship between maintenance programs and the useful lives of investments than to strive to refine the analysis of depreciation costs using insufficient and unreliable data.

Table C-1. Comparison of Depreciation and Interest Charges for Three Methods of Calculating Depreciation.

Year	Straight-Line		Total	Decelerated Depreciation Amortization		Total	Accelerated Depreciation Declining Balance		Total
	Depreciation L.E.	Interest L.E.	L.E.	Depreciation L.E.	Interest L.E.	L.E.	Depreciation L.E.	Interest L.E.	L.E.
1	2,000	800	2,800	1,704.56	800	2,504.56	4,000	800	4,800
2	2,000	640	2,640	1,840.93	663.63	2,504.56	2,400	480	2,880
3	2,000	480	2,480	1,988.20	576.36	2,504.56	1,440	272	1,712
4	2,000	320	2,320	2,147.26	357.30	2,504.56	864	172.80	1,036.80
5	2,000	160	2,160	2,319.04	185.52	2,504.56	1,296[b/]	103.68	1,399.68
Total	10,000	2,400	12,400	10,000.00	2,522.80	12,522.80	10,000	1,828.48	11,829.48

[a/] L.E. 10,000 investment, 5-year life span and 8% interest.

[b/] In this calculation, L.E. 772.00 remained to be depreciated at the end of year 5. This was added to the calculated depreciation for year 5 of L.E. 518.00 to fully depreciate the investment.

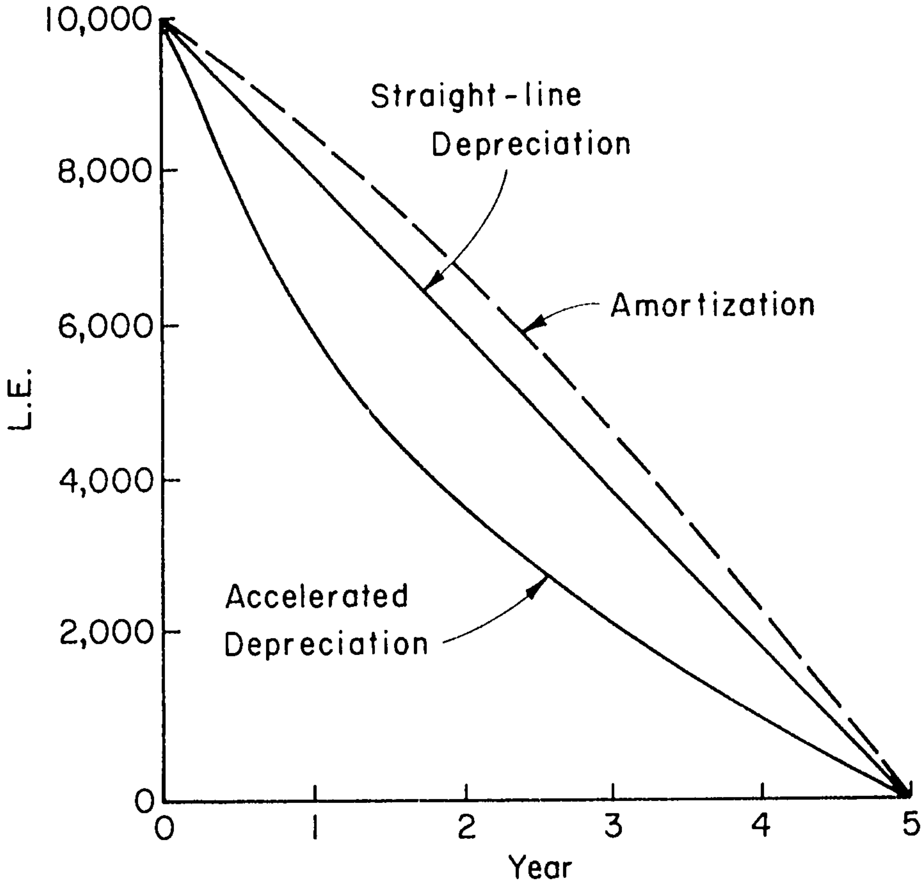


Figure C.1. Undepreciated value of a L.E.10,000 investment with a 5-year life using three methods of depreciation (see Table C.1.)

Appendix D

VALUE OF WATER CONSERVED

At the present time, the Nile can provide more than enough water to meet the needs of the lands being irrigated. Localized water shortages do exist because of either localized inadequacies of the distribution system or because of localized inadequate control. If these local inadequacies can be eliminated by supplying added water, then any additional water supplied has value. That is, increasing the local availability of water can be the basis for generating increased net farm income and increased net value of agricultural output at the national level.

At the present time, on the otherhand, conserving additional water for use in the Nile River System will not generally result in increased national net farm income or increase the national value of agricultural output. This will be true for Upper Egypt even if new lands are expanded as the return flows to the drains can still be used for irrigation on Delta lands.

Pilot projects which conserve water are of value, however, for at least three reasons. First, conservation of water will mean that less water goes into the drainage system, some of which is pumped from the drains back into the distribution system. Second, if water is conserved, the ground-water table problems of water logging and salinity build-up will be lessened. Third, the planned development of new lands will eventually require the conservation of water on old lands, and projects which conserve water establish good habits for the future. It may not be easy to determine an exact value for water conserved, but these three benefits above show that it has a value indeed.

In the case of _Mesqa_ 26, elevation will result in a significant reduction in the water flowing through the _mesqa_ into the drain during the nighttime hours because, as the result of elevation, water is only lifted to the elevated _mesqa_ during times when irrigation is taking place. Preliminary estimates by Abdel Raouf and Esmat Wafik, EWUP engineers at El Minya, indicate that the decrease in water placed in _Mesqa_ 26 as the result of elevating the _mesqa_ may amount to 6400 cu. m. per _feddan_ or nearly 250,000 cu. m. per year.

APPENDIX E

Benefits and Costs of the Pipeline System Proposed for the El-Hammami Canal

Prepared by: Farouk Abdel Al and Melvin D. Skold

The problems identified by Egypt Water Use and Management Project (EWUP) researchers and reported in earlier reports are keys to identifying the expected benefits of a pipeline delivery system. It is expected that a pipeline will provide for (a) a more uniform distribution of water along the branch canal, (b) deliver water on a more timely basis to all farmers along the canal and (c) provide water in volumes adequate to insure efficient distribution of water over the fields. Additionally, the pipeline will (d) save water, making it available for irrigating new lands (e) stabilize the water table and prevent crop yield reductions associated with high water tables and further improve deteriorated soil resources which have accumulated salts over time. Other savings include: (f) savings of canal cleaning costs and (g) freeing land from use as canals enabling an expansion of the cropable land and, perhaps, reducing the amount of land required for drains.

Problems to be corrected by the installation of the pipeline system include:

1. Providing a uniform amount of water available to all lands served by a canal. Wolfe, et al. reported that lands at the end reaches of canals may receive only one-fourth as much water as those at the beginning of the canal (EWUP Technical Report No. 3).

2. Resulting from the poor water distribution, Shinnawi, et al. reported (EWUP Technical Report No. 5):

   a. Farmers near the lower one-third of a branch canal expect maize yields which are less than two-thirds of the expected maize yields of farmers in the upper one-third of a branch canal.

   b. About two-thirds of the farmers in the lower one-third of branch canals have secured access to a pump, either by rental or purchase, while only 10 percent of the upper end farmers use pumps.

   c. Farmers near the lower end of branch canals grow fewer summer crop vegetables and grow more maize than farmers near the upper end of branch canals. The lower end farmers indicated that they would prefer to grow more high-valued vegetables if wate were available in the quantities and times required.

   d. Lower end farmers would also grow more winter vegetables and less berseem; again, increasing their income potentials.

3. High pumping costs for water would be reduced. About two-thirds of the lower end farmers either rent or own pumps. The costs of pump rental or ownership and operation of pumps can be saved.

4. Improved water control as provided by the pipeline system will:

   a. Save water which is needed to irrigate other lands thereby increasing production elsewhere.

   b. Stabilize the water table giving the dual benefits of (a) increased yield from all crops served by the system and (b) reduction in the deterioration of the soil due to water logging and salinization.

   c. Facilitate the application of water to crops according to their evapotransportation needs and with improved efficiency over fields thereby increasing crop yield potentials.

5. Land will be saved by requiring less for distribution of water than is required by canals and improved water control will mean less land is also required for drains.

6. Further, costs of maintaining canals and drains will also be reduced.

Weighting of these benefits and costs can be placed in a partial budgeting framework. The partial budget considers:

A. Expected added returns.
B. Expected reduced costs.
C. A plus B.
D. Expected added costs.
E. Expected reduced pumps.
F. D plus E.
G. C minus F — net benefits (or cost) of the change.

Data are not available which permit a precise calculation of all benefits. Because examples of more optimally controlled water applications are not immediately available in Egypt, benefits from such control can only be based on extrapolations from elsewhere. On the other hand, completion of such a system will enable EWUP researchers to obtain the data necessary for evaluation of other improvements in on-farm water management. It is useful, however, to consider the potential benefits qualitatively as well as quantitatively.

A. <u>Added Returns</u>:

   1. Potential yield increases. The pipeline will serve 780 feddans. The lower one-third (260 feddans), which have lower yield expectations than is the case for upper one-third, will experience increased expected yields.

- Expected maize yields (upper) 10.6 ardabs
- Expected maize yields (lower) 6.7 ardabs
- Difference in expectations 3.9 ardabs
- About 50% of the land is in maize during the summer season or 1/2 x 260 = 135 F of maize, only 1/3 not served by pumps or $\frac{135}{3} = 45$ F.
- 45 F x 3.9 ardab increase = 175.5 ardabs additional maize/year valued L.E. 8/ardab = L.E. 1404.

2. Shifts to higher valued crops.

- Expected net return per feddan of maize 13 ardabs @ L.E. 8 = L.E. 115 less all costs of L.E. 103 = L.E. 7.
- Expected net returns per feddan from:

tomatoes at Beni Magdoul	L.E. 52
artichoke at Beni Magdoul	L.E. 240
cabbage at El Hammami	L.E. 351
eggplant at El Hammami	L.E. 288
AVERAGE	L.E. 218

- Difference, expected returns from vegetables (average) and maize:

  L.E. 218 - L.E. 7 = L.E. 211

- Upper end farmers have about 2/5 of their land in vegetables during summer; lower end farmers without pumps have about 1/5 of their land in vegetables during summer. About 1/3 of the lower end land, (1/3 x 260 = 86.6 F) is not served by pumps.
- 86.6 feddans cropped with $\left(\frac{2/5}{1/5}\right)$ 2 times as many vegetables; vegetables increase of about 17.3 feddans per year with an increased expected gross return of (17.3 x L.E. 211=) L.E. 3,650/year.

3. General yield increases due to: stabilized water table level, improved irrigation efficiency, improved irrigation timing.

   Data to support any assumptions on these matters are not available. Installation of a system to provide control of irrigation water will enable EWUP scientists to learn of the effects of controlled irrigation on water table levels, crop yields, etc.

If we assume a 10 percent increase in overall yields for the 780 feddans served by the pipeline, the value of the additional yield is estimated as:

— Summer crops

Percent of land	Value of Yield	Value of yield + 10%
.55	L.E. 84.8	L.E. 93.28
.45	L.E. 658.0	L.E. 724.35

— Weighted average value of 10% greater yield (.55 x 93.28) + (.45 x 724.35) = L.E. 377.26 less value of existing composite summer crop yield (.55 x 84.8) + (.45 x 658) = L.E. 342.7 = L.E. 34.56.

— Net value of yield increase per feddan of L.E. 34.56 x 780 F = L.E. 26,957.

4. Value of water saved. FWUP engineers have estimated that as much as 15.2 percent of the water may be lost from a branch canal such as th El Shimi Branch. If 2.453 million m^3 of water are delivered each year by the El Shimi Branch and 15.2% of this is lost due to seepage, up to 373 thousand m/u3/d of water could be saved each year.

   Value can be assigned to this water saved (although no value is assigned in this report). Water saved would not infiltrate into the water table and cause its fluctuation resulting in deliterious effects on crop yields and eventual damages to soil quality.

5. Land saved from reductions in the amount of land required for canals 10 m x 4,000 m = $\frac{40,000 \text{ m}\backslash\text{fRu2}}{42,000}$

   = 9.5 F at an annual rental value of L.E. 80/F = L.E. 760/year

B. Reduced Costs:

1. Canal maintenance. 4,000 m of the El Shimi Branch (10 m width) canal must be maintained at an annual cost of L.E. 1,960. This is L.E. 2.51/feddan served (780 F).

2. Drain maintenance is estimated at L.E. 2,500 per year or L.E. 3.20 per feddan served.

3. Reduced water pumping costs. About 2/3 of the lower end farmers either rent or own pumps. Costs . owning and

operating pumps range between L.E. 40 and L.E. 52 per feddan per year. Taking a cost of L.E. 45 per feddan per year for each of the 260 x 2/3 = 174 feddans at the lower end which are served by pumps, total pumping cost savings of L.E. 7,830 per year can be achieved.

C. Added returns plus reduced costs (per 780 feddans served):

Added Returns:

1. L.E. 1,404
2. L.E. 3,650
3. L.E. 26,957
4. n.a.
5. L.E. 760

L.E. 32,771 per year added returns

Reduced Costs:

1. L.E. 1,960
2. L.E. 2,500
3. L.E. 7,830

L.E. 12,290 per year reduced costs

L.E. 45,061 added costs and reduced returns

D. Increased Costs:

1. Annual fixed cost of pipeline L.E. 500,000 estimated at 30 years life (500,000 / 30=) L.E. 16,667.

2. Interest on investment L.E. 500,000 at 10% = L.E. 50,000 per year.

3. Annual operating costs of the pipeline (estimated):

— Maintenance (5% of equipment cost) = L.E. 5,320.

— Electric power.

2 pumps x 10 hr./day x 300 days/yr. x 0.045/KWH (economic price of electricity) = L.E. 13500/year.

— Labor

2 laborers x L.E. 40/mo.
2 technicians x L.E. 60/mo.
(Government rate plus incentive) L.E. 1,680/yr.

E. Reduced Returns: Reduced return estimates are accounted for in the added returns section because changes in net returns were considered.

F. Increased costs plus reduced returns:

Increased Costs:

1.	Annual fixed cost	L.E. 16,667
2.	Interest on investment/yr.	L.E. 50,000
3.	Operating costs, annual	L.E. 20,500
	total, increased costs/yr.	87,167
	Reduced returns	0
	TOTAL	L.E. 87,176

G. C minus F

Added returns plus reduced costs	L.E. 45,061
Added cost plus reduced returns	L.E. 87,167
Benefit (cost) per year	L.E. (42,106)

or 42,106/780 F = L.E. 53.98 per feddan per year

These preliminary calculations indicate an excess of costs over benefits, however, it must be stressed that:

1. Perhaps the most important benefit of a pipeline system is its value for research and demonstration. EWUP analyses have not been able to estimate some of the expected benefits. It is not known:

   — How much yields can increase with reduced and stabilized water tables.

   — How much improved water control can reduce soil deterioration.

   — How much the value of water saved is to downstream users of the water.

   These and other benefits and costs can be more carefully evaluated by installation of such a system. The analyses will be potentially beneficial to other regions in Egypt as well.

2. Costs exceed benefits primarily because of the interest charge on the estimated investment cost.

   (a) If a commonly used World Bank rate of interest on investments were applied, e.g., 3 percent per year, the total annual costs would be L.E. 52,167 against projected benefits of L.E. 45,061 per year, or a benefit of L.E. 7,106 for the project or L.E. 9.11 per feddan served.

(b) Or, if as some argue, interest charge should not be made on public investments, the annual costs reduce to L.E. 25,061 per year with no interest charged. Benefits then exceed costs by L.E. 24,561 per year or L.E. 9.11 per feddan served.

We can also compare between the average costs for lifting water by sakia, diesel pumps versus the cost of water delivered by the new pipeline at El Hammami. The average cost/year/feddan by using sakia is 21.25 LE*, to use diesel pumps it costs 38.40 LE per year** per feddan and the estimated average cost per year for one feddan by using the pipeline will be 26.28 LE. (Using the economic price for Electric power.***) But, if the official price for the first 70,000 KWH of LE 0.020347/KWH, the next 100,000 KWH priced at LE 0.016647/KWH, and the next 130,000 KWH is priced at LE 0.015847 KWH. Water delivery by the new pipeline will be the cost of 15.58 LE per year/ feddan.

* Costs are calculated using staff paper #21 - Water Lifting by Sakia by Forrest Walters, August 1980. Assuming that one sakia serves 10 feddans

** Costs for diesel pumps are calculated based on using a pump 6"/6" for 48 hours per year for one feddan which is the average time for the 3 most common cropping patterns in the El Hammami area and using 0.80 LE as the rental rate for each hour. These three patterns are shown on the next page.

*** The average costs for operating the pipeline system were calculated by using only the costs of electrical power, labor, and maintenance. If we added in addition to these the annual depreciation costs and the annual interest costs, we then come to 66.88 LE/feddan using 3% rate of interest and to 111.75 LE/feddan if a 10% rate of interest is applied.

Pattern	Crops	Period	Irrig. No.	Gross Total Hours					
				Using D. Pumps			Using Sakias		
				# of hours for each irrig.	Total Hours	Gross Total Hours	# of hours for each irrig.	Total Hours	Gross Total Hours
1st	Berseem Meskawy	From Oct. 1 - end of March	12	2.5	30	46	5	60	92
	Maize forage	From Apr. 1 - Sept. 15	8	2	16		4	32	
2nd	Vegetables	From last season to Dec. 15	6	2	12	42	3.5	21	77
	Wheat	From Dec.16 - May 15	7	2	14		3.5	24	
	Maize	June 1 - September 15	8	2	16		4	32	
3rd	Vegetables	September 1 - May 30	20	2	40	56	3.5	70	102
	Maize	June 1 - August 30	8	2	16		4	32	

APPENDIX F

A Preliminary Evaluation of Improvements to Mesqa 10

Abstract

This preliminary economic evaluation on raising Mesqa 10 at Beni Magdul site using the following three sets of assumptions:

1. No yield increase and no production cost increase.

2. Ten percent yield increase and 2.5 percent production increase.

3. Twenty percent yield increase and 5 percent production increase.

This preliminary evaluation shows the potential benefits and costs of this project. The interpretation of the evaluation results for Mesqa 10 shows also that the raised mesqa is going to provide the proper quantity of water to the farm level to permit more efficient on-farm irrigation.

Table of Contents

Introduction

The Egypt Water Use and Management Project (EWUP) has identified inadequate water delivery at the end of water delivery systems as a problem (11, 13).

In effort to solve the problem of shortage of water at the tail of the mesqas, and to eliminate the costs and efforts of labor and animals required for lifting water by sakias and other means, EWUP is constructing an elevated mesqas at Beni Magdul to replace Mesqa #10 which serves approximately 54.6 feddans. The 54.6 feddans are served by 8 sakias (6 sakias are turned by cows, and 2 by donkeys), plus a well at the end of the mesqa served by a diesel pump.

The technical changes required are: constructing a cement line elevated mesqa, beside the existing one, a pump at the head of the mesqa to provide water at the required level and provide sufficient water for irrigation in the proper times to enable the farmers to apply good cropping patterns with good production. In addition, other needed changes are detailed in the pilot program for this mesqa.

The objectives of elevating this mesqa are to provide the proper quantity of water on a gravity feed basis to all farmers on the mesqa. A sufficient head will be provided to allow for fast and more efficient irrigation, also eliminating the need for various on-farm water lifting systems. The elevated mesqa will allow more control of seepage losses which currently are contributing to the high water table, at the same time the replaced mesqa will serve as a drain.

Method of Economic Evaluation

This economic study which presents a pre-feasibility study for Mesqa 10 improvements is a preliminary analysis based on partial budget method of evaluation. The partial budget shows mainly the estimated Benefits and Costs, the general categories of benefits and costs are:

Benefits

A. Added Benefits (benefits added as the result of proposed changes).

B. Reduced Costs (costs for existing system which will no longer occur because of the proposed changes).

Costs

C. Added Costs (costs added as the result of proposed change).

D. Reduced Benefits (benefits from existing system which will no longer occur because of the proposed change).

Net Benefits (costs) = Total Benefits (A + B) - Total Costs (C + D)

The net benefits (costs) calculated become the basis for judging the desirability of the proposed change. If a series of alternatives for proposed changes are to be considered, a partial budget for each alternative must be constructed.

Discount and Interest Rates

In economics, it is generally agreed that the appropriate use of discount rates is the key to the efficient use of capital resources and that interest rates should reflect the opportunity cost of foreign loans, limited interest charges may be made.

Because many Egyptian irrigation improvements are based on low interest loans from international sources, the selection of an appropriate discount rate may involve less of a fundamental conflict. At this point in time, a 4 percent rate for government operations seems to be a reasonable compromise.

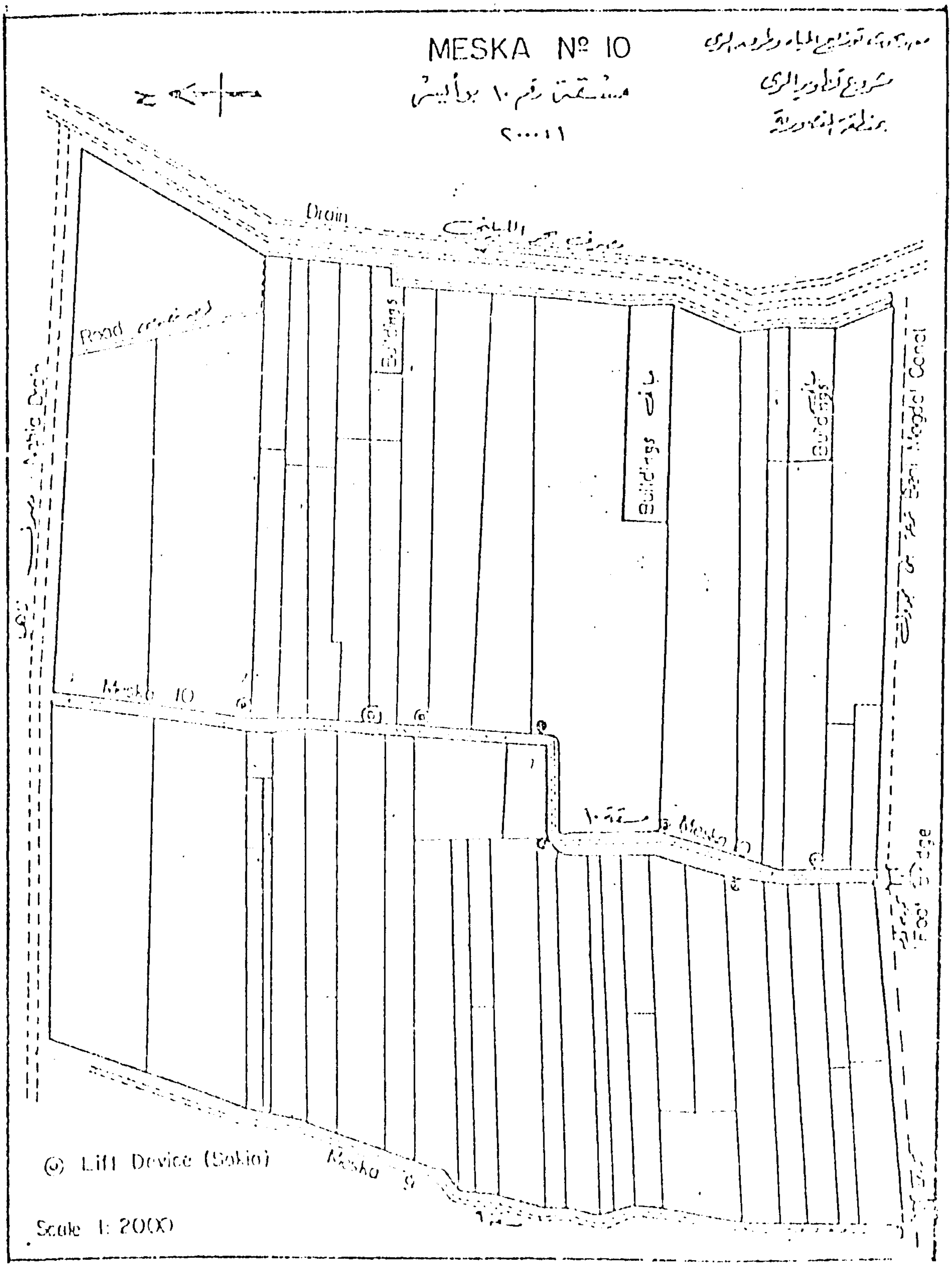
Existing Irrigation Methods

on Mesqa 10, Beni Magdul

Mesqa 10 is located on the left side of Beni Magdul canal. The distribution of the 8 sakias which serve the area are indicated in Table 1 and Map A.

Table 1
Distribution of Sakias on Mesqa 10, Beni Magdul

Right Side		Left Side	
Sakia No.	Area Served	Sakia No.	Area Served
1	5.81	1	3.75
2	5.00	2	8.08
3	6.50		
4	3.71		
5	6.00		
6	15.75		


MESKA № 10
Drain
Road
Buildings
Buildings
Buildings
Meska 10
Meska 10
Foot Bridge
Lift Device (Sakia)
Meska 9
Scale 1: 2000

The cost of lifting water by sakias in the existing irrigation system is estimated according to Staff Paper #21, "Water-lifing by Sakia. The Incremental Cost of Cow Power," by Forest Walters, August 1980, in Table No. 2.

Table 2

Lifting Cost by Sakias (1)

on Mesqa 10, Beni Magdul

Sakia No.	Location	Area Served F.	Annual Cost Per Feddan L.E.	Total Annual Cost L.E.
1	Right Side	5.81	19.21	111.61
2	"	5.00	20.60	103.00
3	"	6.50	18.21	118.37
4	"	3.71	22.68	84.14
5	"	6.00	19.21	115.26
6	"	15.75	15.03	120.49 (2)
7	"	3.75	22.68	85.05
8	"	8.08	17.46	141.08
	TOTAL	54.60		878.99

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(1) We assume that the 8 sakias are turned by cows.

(2) We assume that sakia no. 6 irrigated the area of 15.75 f. for 6 months, and the diesel pump at the end of Mesqa 10 irrigates in the spring and summer (6 months).

Economic Evaluation

for Mesqa 10, Beni Magdul

Alternative Assumption

a. 0% (No yield increase)
b. 10% yield increase, 2.5% cost increase
c. 20% yield increase, 5% cost increase

I. BENEFITS

A. Average Annual Added Benefits

		L.E.
1.	Increased gross profit from yield increase	
	a.	0.00
	b. (688 X 0.10 X 54.60 f. = 3756.48) (3)	3,756.48
	c. (688 X 0.20 X 54.60 f. = 7512.96)	7,512.96
2.	Annual Value of land saved	34.40
	(8 sakias X 25 m^2 / 4200 m^2 = 0.05 f.) 688 X 0.05 f. = LE 34.40	
TOTAL AVERAGE ANNUAL ADDED BENEFITS	a.	34.40
	b.	3,790.88
	c.	7,547.30

B. Average Annual Reduced Costs

1. Lifting by sakias (a, b, c) 878.99

---

(3) Average crop production value per feddan = LE 688
Data from 1979/1980 - Beni Magdul Farm Record Summary

L.E.

2. Lifting by diesel pump (a,b,c) 519.75

(15.75 f. X 2 month X 3 times X 2 hours X 0.75 = LE 141.75)

+ (15.75 f. X 4 month X 4 times X 2 hours X 0.75 = LE 378.00)

3. Labor to distribute irrigation water (a,b,c) 1,583.50

Old Mesqa

54.60 f. X 4 winter months X 2 times/month X 4 h = 1747 h

54.60 f. X 4 spring & fall mo. X 3 times/mo.X5 h = 3276 h

54.60 f. X 4 summer months X 4 times/month X 6 h = 5242 h

Total irrigation hours 10,265 h

Elevated Mesqa (4)

54.60 f. X 4 month X 2 times X 2 h = 874 h

54.60 f. X 4 month X 3 times X 2 h = 1310 h

54.60 f. X 4 month X 4 times X 2 h = 1747 h

Total irrigation hours 3931 h

Number of hours saved = 10265 - 3931 = 6334 h

Labor hours costs saved = 6334 X LE 0.25 = LE 1583.50

---

(4) Number of hours needed for gravity irrigation for one feddan is 2 hours. The engineering calculation was 1.55 h per 1 feddan.

4.	Mesqa Maintenance (a, b, b)		120.00
	20 laborers x LE 2.00/day x 3 times		________
B.	Total average annual reduced costs		3,102.24
	Average Annual Total Benefits (I A+B)	a.	3,136.64
		b.	6,893.12
		c.	10,649.54

II. Costs

C. Average Annual Added Costs

		LE
1. Average annual depreciation (5)		662.60
- Earth work LE 112/20 = LE 5.60		
- Structures LE 12500/20 = 625.00		
- Gates LE 320/10 = LE 32		

	LE	
2. Pumping annual cost (6)		1,102.50
- Fixed costs (depreciation) D. pump 16.5 hp LE 1450/10 yrs=145	145.00	
- Operating costs (1 labor x LE 30/month x 12 mo.=360)	360.00	
- Fuel costs D fuel 3 liter/hr x 3931 hr x LE 0.03 = 353.79) Oil fuel 0.08 kg/hr x 3931 hr x LE 0.775 = 243.72)	597.50	

	LE
3. Maintenance	
- Earth work	0.00
- Gates (8 gates x LE 4 = 32)	32.00
- Structures (LE 12500 x 0.01 = 125)	125.00
- D. pump (LE 1450 x 0.05 = 72.5)	72.50

---

(5) Estimated useful life
- 20 years for earth work and structures
- 10 years for gates and D. pump

(6) If we used electric pump we have to re-calculate the electric power charge.

			LE
4.	Annual interest on average investment		287.64
	(earth work LE 112 + structures LE 12500 + gates LE 320 + pump LE 1450 = 14382 LE 14382/2 x 0.04 = 287.64)		
5.	Drain Maintenance		60.00
	Old mesqa 10 will serve as a drain 15 labors x 2 days x LE 2/day		
6.	Crop production cost increase (7)		
	- a. LE 134 x 54.60 f x 0 = 0.00	a.	0.00
	- b. LE 134 x 54.60 f x 0.025 = 182.91	b.	182.91
	- c. LE 134 x 54.60 f x 0.050 = 365.82	c.	365.82
C.	Average annual total added costs		
		a.	2,342.24
		b.	2,552.15
		c.	2,708.06
D.	Average annual reduced benefits		0.00
	Added costs + reduced benefits C + D	a.	2,342.24
		b.	2,525.15
		c.	2,708.06

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(7) Average crop expenses per feddan = LE 134 from 1979/1980 Beni Magdoul Farm Record Summary.

NET BENEFITS (A+B) - (C+D)

a.	3,136.64 - 2,342.24 =	LE	794.40
b.	6,893.12 - 2,552.12 =	LE	4,341.00
c.	10,649.54 - 2,708.06 =	LE	7,941.48

Interpretation of the Evaluation Results for Mesqa 10 at Beni Magdoul area

The average annual net benefits using the (a) set of assumptions (no yield increase, no production cost increase) are estimated to be LE 794.40. The average annual net benefits using the (a) set of assumptions (no yield increase, no production cost increase) are estimated to be LE 794.40. The average annual net benefits per feddan will be LE 14.55. It is reasonable to expect that there will be a yield increase if the farmers took advantage of the improved irrigation system and if the proposed Farmer's Organization can provide enough discipline to maintain the required farmer schedule for irrigating. However, the average annual net benefits using the (b) set of assumptions (10 percent yield increase and 2.5 percent production cost increase) are estimated to be LE 4.341.00. This amounts to a net benefit of LE 79.51 per feddan.

The average annual net benefits using the (c) set of assumptions (20 percent yield increase, and 5 percent production increase) are estimated to be LE 7.941.48. The average annual net benefits per feddan will be LE 145.45.

This preliminary economic evaluation using three sets of assumptions shows the benefits of this project which the raised cement lined mesqa can provide, i.e., the delivery of the proper quantity of water to the farm level to permit more efficient on-farm irrigation as well as allowing more control of seepage losses which in old mesqas are contributing to high water tables.

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AMERICAN EQUIVALENTS OF EGYPTIAN ARABIC

TERMS AND MEASURES COMMONLY USED

IN IRRIGATION WORK

Land Area	*in sq meters*	*in acres*	*in feddans*	*in hectares*
1 acre	4,046.856	1	0.96335	0.40469
1 *feddan*	4,200.8335	1.03805	1	0.42008
1 hectare (ha)	10,000.00	2.47105	2.38048	1
1 square kilometer	100×10^4	247.105	238.048	100.00
1 square mile	259×10^6	640.00	616.4	259.00

Water Use	*in acre-feet*	*in acre-inches*
1 billion m^3	810,710	
1,000 m^3	0.81071	9.72852
1,000 m^3/*feddan* (= 238 mm of rainfall)	0.781	9.372
420 m^3 rainfall (= 100 mm of rainfall)		

Other Conversions	*metric*	*U.S.*
1 *ardab*	198 liters	5.62 bushels
1 *ardab*/*feddan*		5.41 bushels/acre
1 kg/*feddan*		2.12 lb/acre

Egyptian Units of Field Crops	*Eg. Unit*	*in kgs*	*to convert Eg. units/feddan to tons/ha, multiply by*
Cotton (unginned)	metric *qint…*	57.5	0.3749
Cotton (lint or ginned)	metric *qintar*	50.0	0.1190
Sugar, onion, flax straw	*qintar*	45.0	0.1071
Rice (rough or unmilled)	*dariba*	945.0	2.2496
Lentils	*ardab*	160.0	0.3809
Clover (*bersim*)	*ardab*	157.0	0.3737
Broadbeans, fenugreek	*ardab*	155.0	0.3690
Wheat, chickpeas, lupine	*ardab*	150.0	0.3571
Maize, sorghum	*ardab*	140.0	0.3333
Linseed	*ardab*	122.0	0.2904
Barley, cottonseed, sesame	*ardab*	120.0	0.2857
Groundnuts (in shells)	*ardab*	75.0	0.1785