AGRICULTURAL ECONOMICS

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Staff Paper SP-76-5 August 17, 1976

IMPROVING THE FRAMEWORK FOR ESTIMATION OF AGRICULTURAL BENEFITS OF SMALL WATERSHED PROJECTS

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Paper presented at American Agricultural Economics Association Annual Meeting, August 1976

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Abstract

Techniques of agricultural benefit estimation for small watershed projects have recently become the focus of increasing study and controversy. An alternative approach to agricultural benefit estimation is compared to current techniques on both a general level, and by reference to a case study. Improvements in estimation techniques may be possible.

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Introduction

The economic impact of the Small Watershed Program [P.L. 566] has recently become the focus of both increasing study and controversy. Recent studies have shown great variability between projects when ex-post realized benefits were compared to ex-ante projected benefits. [Little, A.D., Sutton, Mattson]. Meanwhile, recently proposed projects have often met with environmental opposition, which has frequently been supplemented by criticism of the projects economic analysis. [Chicod]. Thus, both ex-post program reviews and specific controversy have recently come together to focus attention on the Soil Conservation Service's (S.C.S.) approach to benefit-cost analysis. Since agricultural benefits comprise a large part of total program benefits and reflect the primary mission of the watershed program, they are of particular concern.

The ex-post studies of agricultural benefit estimates conclude that current estimation procedures do not adequately address key assumptions about the likelihood of land treatment and land use changes, as well as the broad economic factors which affect farm operator behavior and upon which project success depends. Two recent studies have concluded:

> Present projections of land use changes resulting from project installation rely heavily on stated intentions of farmers, and on land use capability and soil productivity. This study indicates that other factors should be considered as well. These include increased off-farm employment opportunities, available farm labor, supplies of labor and capital to carry out land use conversions, and long-term trends for crops suited to local climate and soils and the developing patterns of farm size and organization. [Mattson, p. vi.].

> Many factors other than a watershed project's management of the water resource affect landowners' decisionmaking. These factors are significant because they reflect the socioeconomic environment within which the projects must function. Planners need to be cognizant of them in estimating future impacts. [Sutton, p. vi.].

Criticism of current agricultural benefit estimation techniques is also reflected in controversy over specific projects. In November 1971, plaintiffs requested a preliminary injunction against the Chicod Creek channelization and drainage project. SCS has since filed environmental impact statements (EIS) to meet the plaintiff's and the court's concern over the inadequacy of the projects environmental and economic analysis [NRDC, 341; NRDC, 355]. However, an analysis of the summary comments from the December 1974 EIS reveals that concerns with the economic analysis of agricultural benefits continue to exist. (Table 1).

Table 1

Comments in Chicod Creek Revised Final EIS [Chicod]

	---- number ----
Total Comments	396
Comments on all Economic Issues	164
Comments on Agricultural Benefits	92
Likelihood of Land Treatment	26
Likelihood of Land Use Change	19
Likelihood of Project Maintenance	21
General Agri. Benefit Estimates	26
Other Economic Comments	72

This paper will propose a process for estimating agricultural benefits that can address the criticisms and concerns noted above. First, differences between the current SCS approach and the proposed alternative will be generally highlighted. Then the results of a case study using the SCS approach and the proposed alternative approach will be compared.

Factors Determining Agricultural Benefits

Project planners should explicitly consider economic variables that will affect the environment within which farm firms operate. Watershed projects to control erosion, sedimentation and flood damage and/or provide drainage or irrigation affect the technical production possibilities on a given farm. However, individual farm operators will only take advantage of improved technical possibilities if the economic environment favors such action.[1/]

Table 2 highlights the causal factors which interact to determine the agricultural benefits of a project. In general, the projects impacts on technical production possibilities of the farm and the farm economic environment are exogeneous factors which may influence the behavior of individual farm operators in the project area. These exogeneous factors determine the quantities of inputs used and the resulting outputs (as well as land use), and the willingness of the farmer to utilize land treatment practices.[2/] The difference in net returns to the farm operation, with and without the project, are the estimated agricultural benefits. Thus, changes in the economic environment can affect farmer behavior which in turn will

Table 2

Causal Factors Determining Agricultural Benefits

EXOGENEOUS INFLUENCES	FARM OPERATOR BEHAVIOR	AGRICULTURAL BENEFIT OF PROJECT
A. Project Impacts on Technical Production Possibilities 1. scale of project 2. potential for yield increases on existing cropland by reducing water damage to crops 3. potential for conversion of pasture, woodland, and marshland to cropland 4. potential for more intensive land use (ex. irrigation, drainage) 5. quality of crop produced can increase B. Interactions in Farm Economic Environment 1. relative output prices 2. relative variable input prices 3. opportunity cost for fixed factor inputs (off-farm income, land prices) 4. farm tenure 5. farm size 6. input constraints 7. crop rotation requirements 8. agricultural policies 9. production technology available 10. yields without the project 11. quality of crop without the project 12. proportion of farm with problem land 13. trends in local economy (migration, total land use, economic growth)	Patterns of land use based upon output and factor input use decisions, including land treatment, are determined.	Net return to farm operation with and without project.

alter the time stream of benefits from a project. At the extreme, for example, exogeneous increases in off-farm incomes relative to on-farm incomes may result in some operators ceasing production thus, reducing future benefits of the project.

General Comparison of Techniques

Currently use of enterprise budgets is the basis for agricultural benefit estimation. Of concern is whether this technique adequately reflects the scope of issues and direction of causality depicted in Table 2. This question can, in part, be answered by comparing the characteristics of this approach with a proposed alternative built around a simple programming framework.[3/]

Current SCS Procedures: The SCS Economics Guide recommends the use of farm enterprise budgets as a means of calculating agricultural benefits. [SCS, Guide, p. 6-3]. Using price and yield data without the project, for a "typical" acre of land, gross returns per acre are calculated. Production budgets are used to calculate costs per acre, and existing net returns without the project per acre are computed. The impact of the project on technical production possibilities (Table 2) are then considered in a new budget analysis. The difference between the computed net returns per acre with and without the project are the gross agricultural benefits of the project on a per acre basis. Multiplication by the number of acres benefited and subtraction of associated costs (land treatment) complete the computation. At times considerations of future trends in some key variables, such as prices, may be incorporated in the analysis, although such action is not a required step [Chicod].

A Proposed Alternative: The analytic procedure proposed here combines a programming technique with projection techniques for key variables to estimate net farm income due to the proposed action over time. Specific steps followed are:

1. Identify length of the projects economic life and determine the time intervals, for example five year increments, for which benefit analysis will be undertaken.

2. Develop a framework for a programming model that incorporates factors identified in Table 2. The detail and size of the model will depend upon the expertise of the analyst, the economic significance (cost) of the project to be analyzed, available data and available time. Simple linear programming may be suitable in one instance while more sophisticated programming models may be necessary in other cases.

3. Project key exogeneous variables for each time period to be analyzed. Projections should be primarily based upon analysis done outside the specific project planning process by agencies such as the Water Resources Council.

4. Solve the model for each time period under consideration to determine net incomes with and without the project.

5. Examine results to identify important factors determining agricultural income estimates and/or perform sensitivity analysis to isolate these factors. Where appropriate make modifications or extensions in data and/or model design.

A completely detailed differentiation of the two approaches is not possible within the confines of this discussion. Instead, Table 3 is presented to highlight some of the key differences between the two approaches as they treat the items listed in Table 2. The strengths of the proposed approach, when compared to current SCS techniques are indicated. On each item the proposed approach is an analytically superior means of capturing the interrelationships shown in Figure 2.

Table 3

Comparison of Alternative Agricultural Benefit Estimation Techniques
Based Upon Analytic Values for Key Items from Table 2

Item for Comparison	SCS Application of Enterprise Budget	Proposed Approach
definition of agricultural benefits of project	differences in net returns to farm operation with and without the project. [S.C.S. Guide, p. 3-17].	same
land use in project impact area with and without the project, including changes in cropping pattern and conversion of pasture, woodland, and marshland to cropland	treated as being determined outside the specific physical impacts of the project and the individual farms economic environment. Often projected to be unchanged or changes projected on basis of crop production patterns and land conversions in larger project region. [S.C.S. Guide, P. 5-15; Chicod, pps. B-15 - B-17].	explicitly recognizes argument depicted in Table 2, by letting farm land use changes be determined by the analytic framework, as farmers maximize net returns within constraints of their economic environment. This allows the analyst to explicitly consider relevant factors which can change land use over time within the context of the farm operations directly affected by the specific project.
acres of land likely to receive land treatment	treated as being determined outside of projects physical impact and the farms economic environment. Often predicted based upon "past experience" gathered over a wide range of projects over all types of cropland. [Chicod, p. B-18].	determined by the analytic framework based upon farm operators desire to maximize net economic return. The focus upon farmer behavior allows the analyst to carefully consider how future conditions may raise or lower the level of land treatment.
with project yields from crop damage reduction	proportionally improved over without project yields	same

Table 3. Continued.

Item for Comparison	SCS Application of Enterprise Budget	Proposed Approach
land use intensity	assumes farmers will plant earlier, fertilize more heavily, etc. [Chicod, p. B-11]	assumes farmers can use land more intensively. The decision to do so is made dependent upon the farm economic environment. Intensity of land use is determined within the analytic model.
quality of crop	determined by physical impact of project	same
relative output prices, relative input prices	usually constant over time. Often "normalized" to account for cycles in price movement [S.C.S. Handbook, p. 1-6]	projected over time based upon expected trends in the general agricultural economy. Sensitivity of analytic results to relative price change can be easily examined.
farm tenure	ownership assumed	rental, sharecropping, or ownership may be examined in model by alterations in behavioral assumptions or costs. Variability in tenure will affect realization of project benefits.
farm size	normally an "average" acre of "average" farm is analyzed. Scale economies are not often considered.	variable farm sizes are built into model to take explicit consideration of scale economies. This also allows for considerations of farm size changes over time. Different size farms will have different willingness and ability to make adjustments to take advantage of the project.

Table 3. Continued.

Item for Comparison	SCS Application of Enterprise Budget	Proposed Approach
input constraints	all inputs are assumed to be available in quantities required by farmer at a prevailing price, that will allow farmer to take full advantage of project impact	constraints on availablity of inputs are explicitly recognized. When such constraints influence farm production patterns they may be directly analyzed and modified as appropriate. For example, additional labor may be hired, but at a higher wage rate.
crop rotation requirements	allocation of land to different crops is not considered in context of individual farm requirements such as crop rotation	explicitly recognized as a constrainting influence on production decision made by the farm operator
production technology	assumed same for all farm sizes over life of project	variable by farm size and tenure with the need to project changes in technology in response to changing economic conditions
yields without the project	either assumed to remain constant over time [Chicod], or increase modestly [A.D. Little, I, p. 285].	must be projected over time to reflect changes in success of extension and research programs
agricultural policy	focuses upon crop allotment programs with assumption of total use of allotment [Chicod], and slow or zero growth in allowable production over time [S.C.S. Handbook, p. 4-4].	built into model directly as production constraint, and/or price incentive depending upon program considered. Input subsidies (ex. REAP) can be built in as cost difference.

Table 3. Continued.

Item for Comparison	SCS Application of Enterprise Budget	Proposed Approach
proportion of farm subject to flood/ drainage problem	often not considered [Chicod]. Only problem acres are analyzed as if they were independent of other factors in the farm operation.	recognizes the farm as whole unit that makes production adjustments between land uses in response to physical and economic environment. Furthermore, viewing problem land as component of total farm operation allows direct consideration of scale economics and other factors dependent on total farm size
farm enterprise changes	changes not usually considered. If considered, are related to general regional economic trends in agricultural economy.	numerous enterprises can be built into the analytic framework to identify possible changes over time with changing farm economic environment for specific project area.
interaction of causal factors	limited to changes the analyst wishes to project over time, often based upon non-project considerations such as general economic trends	primary goal of model is to solve for enterprise and input substitutions that will result from changes in the farm operators environment and technical production possibilities
treatment of time	analysis may require projections of some variables. [S.C.S. Guide, Chapter 15] However, the variables to be projected are not identified in the context of the particular farm operations.	analysis accomplished in increments over time to reflect changing projected conditions. Analytic framework itself suggests particularly sensitive assumptions about future conditions which can aid in the projection process. For example, the programming framework may suggest input constraints that are important determinants of benefits over time.

Application to a Case Study

In order to compare the two approaches to benefit estimation, applications of the SCS enterprise budget and the programming approach[4/] were used to estimate the agricultural benefits of the Chicod Creek project.[5/]

As noted earlier, the Chicod Creek project has been delayed for several years. This delay offers particular benefits for this comparison. First, the extended review of project merits has made a large amount of data on the project available for use. Second, the delay provides a chance to examine the impact of actual variation in the economic environment over time on agricultural benefit estimates. Third, the project critics have claimed that SCS estimates on the likelihood of land use change and land treatment are not realistic.

The estimation of agricultural benefits, land treatment, and land use change using SCS techniques, are compared to the estimations obtained with the programming approach. Data for 1964 and 1974 were analyzed using the two separate methods.[6/] The SCS approach was followed as it was described in the EIS, although slightly different data were used. The programming approach used the same basic data. Additional data on many factors that were not considered in the SCS approach (e.g., farm size) were also utilized. Data sources and assumptions are outlined in Appendix A.

Land Use Change: The EIS concludes that there will be no change in land use due to the project. Their analysis of trends and "data obtained through farmer interviews revealed that farmers expressed no intention of increasing crop acreages as a result of project installation. Therefore, the same acreages are used for both future 'without' and 'with' project." [Chicod, p. B-14]

Within the programming framework, however, land use can change depending on the relative profitability of the enterprises and the resources available.

Estimates of land use changes with the project are presented in Table 4.

Table 4

Estimated Changes in Land Use With and Without the Project

	Programming Approach		SCS Approach	
	1964	1974	1964	1974
	---------- acres ----------			
Corn	436	1411	0	0
Soybeans	1076	0	0	0
Tobacco	- 7	- 8	0	0
Peanuts	52	0	0	0
Woodland/Marshland	-1556	-1403	0	0

As the table indicates, with the project it becomes profitable to clear woodland/marshland and grow more corn, soybeans and peanuts in 1964 and more corn in 1974. Note also that tobacco acreage is estimated to decrease when the project is established. Thus, it appears that the installation of the project may well induce farmers to change their crop mix as relative profitabilities change. The programming approach seems to be a much sounder basis for estimating likely changes in land use that is given in the EIS.

Land Treatment: Land treatment was mainly construction of on-farm drainage measures. Without land treatment, it was argued, none of the predicted agricultural benefits of the project could be realized. Failure of individual farm operators to install and maintain these measures reduces project benefits in proportion to the acres not treated. Thus, critics of the project felt that unless suitable "guarantees" that land treatment would be undertaken could be obtained the project benefits may not be obtained. SCS agreed that all land treatment would not be installed and "assumed, based on observance of social behavior of people that 20 percent of the on-farm drainage measures necessary to achieve maximum potential benefits will not be installed." [Chicod, p. B-18]

However, the programming approach examined the returns to land treatment in 1964 and 1974 and was able to suggest the proportion of land needing treatment that farm operators could profitably treat. While the SCS assumed 80 percent of all acres would be treated in both 1964 and in 1974, this analysis showed that it would pay to treat all land under 1974 conditions, but in 1964 only 26 percent of the land would be treated. Quite simply, it appears that land treatment would have been less likely in 1964 than 1974. Yet the SCS procedures do not recognize this difference.

Agricultural Benefit Estimates: Although the agricultural benefits are defined similarly, application of the two approaches gave different benefit estimates, as shown in Table 5.

Table 5

Net Agricultural Benefits Estimates

Year	SCS Approach	Programming Approach
1964	186,805	54,549
1974	303,678	125,748

It should be reemphasized that these estimates are not meant to reflect the "true" benefits of the project since the available data base was limited. Indeed, whether the SCS approach will provide higher or lower estimates can not be determined *a priori*.

In this particular example, the difference appears to stem from the manner in which farm units were treated in the two approaches. Recall that the programming approach treats farms as whole units having some proportion of problem land, while the current approach analyzes only the problem land independent of the total farm operation. In this particular instance, the programming approach indicated that no tobacco would be grown on problem land either with or without the project. To the extent that farms only have problem land these results are biased. Thus an expanded information base may be necessary to represent "typical" farm situations.

Summary

The case study results comparing the two approaches for the years 1964 and 1974 demonstrate the importance of projecting key economic variables. When land use and land treatment are treated as dependent on farm operator behavior in the project area, their likelihood varies with changing economic conditions over time, and this is explicitly recognized in the programming framework. Clearly the pattern of land use changes and use of land treatment are essential if benefits are to be accurately estimated. Therefore, the accuracy of the estimates using the programming approach will probably be superior.

A particular value of the programming approach is that it forces the analyst to consciously examine key assumptions for their validity and implications. For example, in 1974 it was estimated that farm operators would treat all land affected by the project. It may seem unlikely that this would readily occur, and the programming technique can be used to directly assess the implications of the estimates made about factors such as farm tenure, farm size, ability of operator to borrow funds, etc. on this conclusion. Modifying these estimates will indicate how sensitive the likelihood of land treatment is to these estimates. Such re-analysis is not possible with the SCS approach to land treatment likelihood.

Conclusions

The proposed approach appears able to provide satisfactory answers to some of the key questions program analysts and specific project critics have identified. However, implementation of this approach will require some changes that may strain the resources available to the SCS offices. Table 6 below, indicates how the resources to complete the analysis may differ between the two approaches.

Table 6

Item	SCS Application of Enterprise Benefit	Proposed Approach
data base required	relatively narrow with surveys to acquire primary data limited in size	broader for a point in time and there is a need to project more variables over time. However, information is available from secondary sources. Surveys need to be made more detailed to cover more farm units.
expertise	budgeting skills	knowledge of the programming framework and more detailed interpretive skills. Can be gained in basic college curriculum or special training course for current employees.
cost of analysis	relatively lower in terms of both time and financial costs	probably higher, but not significantly so. Benefits of gained precision are large.

Footnotes

1. This general proposition is explicitly recognized in the SCS Economics Guide when it states: "Several physical, social and economic factors govern the amount of change, restoration or intensification [of farmland use] that will result. . . [from the project]. [Soil Conservation Service, p. 4-3].

2. Land treatment measures, performed by the farm operator, must be completed before the project can affect the farms production possibilities. Failure of landowners to conduct land treatment negates the potential gains from the project. "Land treatment measures are the basic element of any watershed project. . . . all other measures shall be justified for inclusion in the project on the basis that land treatment measures. . . have been installed" [Soil Conservation Service, p. 2-1].

3. The programming approach to benefit estimation has been suggested elsewhere. [Day, James, Kaul]. However, these studies generally show how flood plain land use can be optimized. The intention here is to examine whether such techniques can improve agricultural benefit estimates.

4. Space does not permit full discussion and documentation of the data and the model in the text. Appendix A will provide a brief overview of these issues.

5. The intent of this is <u>not</u> to critique this project <u>per se</u>. In fact, a complete analysis of the project will not be presented. Also, even with the ready availability of much data, the data base that now exists to these authors cannot allow for a completely satisfactory application of their proposed framework to this case.

6. The results in the EIS were not exactly replicated by the use of the budget technique due to the need to use a slightly different data base to make the programming and budget technique comparable in this paper.

APPENDIX A

The following information provides documentation of the data sources and assumptions used in the programming model. This information is provided in a format similar to Table 3 to ease interpretation.

Item	Source and/or Assumption
Definition of agricultural benefits	Net increase in returns to the farm operation.
With project yields	Project yields for 1964 from Environmental Impact Statement [Chicod]. Project area yields for 1974 based upon Extension Service Publications for "typical" farms [Circular 522, Record Book 63, Miscellaneous ...126].
Input usage	Input usage was estimated utilizing standardized budgets from the Extension Service. [Circular 522, Record Book 63, Miscellaneous... 126].
Output prices	Output prices for 1964 were from the EIS. Output prices for 1974 were based upon "expected" prices reported by the Extension Service. [Circular 522, Miscellaneous...126].
Input prices	Input prices were estimated from Extension Service Publications. [Circular 522, Miscellaneous...126].
Farm tenure	Ownership assumed.
Farm size	Three farm sizes were utilized. Assumed farm size distribution in the watershed was the same as in Pitt and Beaufort Counties. County data obtained in the 1964 Census for 1964 and the 1969 Census for 1974

Item	Source and/or Assumption
Input constraints	Land constraints were estimated using the EIS data and the Censuses. Annual labor, peak period labor and capital constraints came from [Little].
Production technology	Production technology and scale economies were estimated by farm size based on [Little].
Without project yields	For 1964 the EIS estimates were used. For 1974, it was assumed that the same relationship between with and without project yields in 1964 held in 1974.
Proportion of farm subject to flood/drainage problems	It was assumed that each farm in each size category had the same proportion of flood/drainage prone land as the proportion in the watershed as a whole.
General agricultural economy	Assumed that changes that occurred in Pitt and Beaufort Counties also occurred in the watershed. The 1964 and 1969 Ag. Censuses were utilized to obtain changes in farm numbers and acreages by size category.
Agricultural policy	Governmental acreage and poundage restrictions were estimated for peanuts and tobacco, respectively.

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