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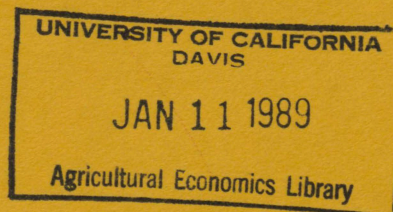
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Getting Computer Technology to Small-Scale Farmers: A Preliminary Assessment

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Abstract

The major objective of this research project is to quantify the benefits of microcomputer uses and applications for small-scale farmers. Major phases of the project include: 1) development of computerized decision aids for small-scale farmers; 2) training of farmers in the use of technology; and 3) measurement of the benefits through evaluating economic performance over time.

The first phase of the research produced INTEG. INTEG is an integrated set of Multiplan templates that allows for 1) planning farm operations and financial activities; 2) records management in terms of monitoring actual vs. intended levels of financial activity; and 3) cost control through enterprise budgeting and production efficiency analysis. The INTEG system is being used in five counties to help farmers plan, monitor, and control their operations. After the first year, average net benefits to participating farmers were estimated at \$1,500 to \$1,800. The benefits were measured as the monetary value of reduced expenditures, different resource allocations and/or improved money management.

Introduction

Farmers' use of microcomputers as a management tool has become a real phenomenon in the last few years. The cost of microcomputers, unlike the cost of other agricultural production inputs, has been declining, placing the computer within the budgetary constraints of smaller operations. The question remains as

to the possible implications of wide-scale adoption of this technology as it affects farm viability.

In the past, technological innovations have increased the concentration of production toward larger, more specialized units (James and Pugh, 1968; Holland, 1980; Osborn, 1981). The characteristics of computers suggest that significant economies of size may be associated with their adoption and utilization. If such technology imparts a significant competitive advantage to the farm user, then farmers who adopt and use the new technology effectively can be expected to have a greater probability of surviving and expanding their operations. On the other hand, small farmers without access to computer power may be at a significant short-term and long-term disadvantage. However, the rate of adoption of computers has not been as rapid as expected because of a number of factors. According to King (1985), these include an extraordinarily rapid rate of technological change in information technology, which has discouraged farm investment because of a fear of obsolescence; widespread financial stress in the farm sector, which has reduced levels of investment in general; and farm information systems and information services that often do not meet the needs of farm managers. To determine what these needs are we must understand the decision-making behavior of farmers.

In the Organization for Economic Development's (OECD) study on the "Social Assessment of Technology" (1978), attention is drawn to the dynamic nature of new and still only partially evaluated technology. The report emphasizes the importance of an iterative process in determining the impact of a new technological

development (OECD, 1978). They suggest that:

The most satisfying approach seems to be a convergent investigation of needs and demands of the potential users on the one hand and of the opportunities and promises of new technological discoveries on the other. Critical comparison of the two trends leads to the choice of particularly interesting technological developments, among which the most promising one can be distinguished as the pivotal objective of the analysis. (OECD, 1978:25)

This approach suggests that an investigation of the impact of such a multifaceted and flexible technology as the microcomputer must be iterative. The essential problem is to determine which group or groups of farmers could benefit most from the adoption of microcomputer technology and then determine optimal hardware and software combinations that are appropriate. There are as many configurations for the packaging of computer technology as there are applications for their use. Furthermore, the technology must be available in both the physical and economic sense; that is, it must be within reasonable proximity and it must be affordable.

Objectives

The major objective of this research project is to quantify the benefits of microcomputers applicable to small-scale farmers. Major phases of the project include: 1) development of computerized decision aids

for small-scale farmers; 2) training farmers in use of the technology; and 3) measuring benefits by comparing economic performance over time.

Background literature: Computer functions as they relate to measuring value

The computer can be useful in three major areas: Electronic Data Processing (EDP); Management Information Systems (MIS); and Decision Support Systems (DSS).

Electronic Data Processing (EDP) consists of observation, classification, and storage of data that usually produce standardized reports, i.e. balance sheets, herd status, etc. To evaluate such a system we must compare the new system with the previous one in average processing time, labor loading, and equipment cost (Keen and Morton, 1978).

Management Information Systems (MIS) is classified as an Operations Research/Management Science, with the emphasis on structured problems where the objective, data, and constraints can be perceived (Keen and Morton, 1978). Measurement criteria include profitability, application to major problems, quality of decisions, user satisfaction, and widespread use (Ein-Dor and Segev, 1981).

Software included in Management Information Systems is for linear programming, ration balancing, and

lease/buy decision-making.

With Decision Support Systems (DSS), the emphasis is on semi-structured problems for which the computer can be used as an analytical aid, but for which management judgement is essential (Keen and Morton, 1978).

Measurement criteria center on extending the range and capability of managers' decision processes to help improve their effectiveness in terms of decision outputs, changes in the decision process, changes in managers' concepts of the decision situation, procedural changes, classical cost/benefit analysis, service measures, managers' assessment of the system's value, and anecdotal evidence (Kleen and Morton, 1978).

The software commonly classified as DSS includes simulation modeling, electronic spreadsheets, market forecasting (charting), statistical analysis, management games, and teaching modules.

We can observe that the measurement criteria for EDP and MIS are more easily quantified than criteria for DSS. These differences, which we will explore in greater detail, are essential for isolating proper measurement criteria. The differences emphasize the need for behavioral analysis, especially in the case of DSS.

The Management Systems Research Model

The Management Systems Research model developed in a previous study by Mu'min (1987) is designed to measure the value of an improved information system, in which behavior is accounted for as well as physical performance. The measurement system shown in Figure 1 includes five major activities. They are selection of farm system, behavioral analysis, measurement of effectiveness, testing behavioral predictors of effectiveness, and quasi-experiment.

Results of the implementations of the first four steps of the model demonstrated that managerial effectiveness could be predicted by a subset of the managerial questions focusing on cost realization and financial decision-making. The outputs of these phases included a decision-making questionnaire composed of questions that were shown to be significantly associated with farm managerial effectiveness. Other outputs from phases 1 through 4 were used in the selection and development of decision aids for the decision support system described below.

Quasi-experiment

Implementation of the first four stages also sets the stage for actual measurement of the value of an improved Decision Support System (DSS). The mode of evaluation is direct measurement via a quasi-experiment. Measuring the value of information through comparative

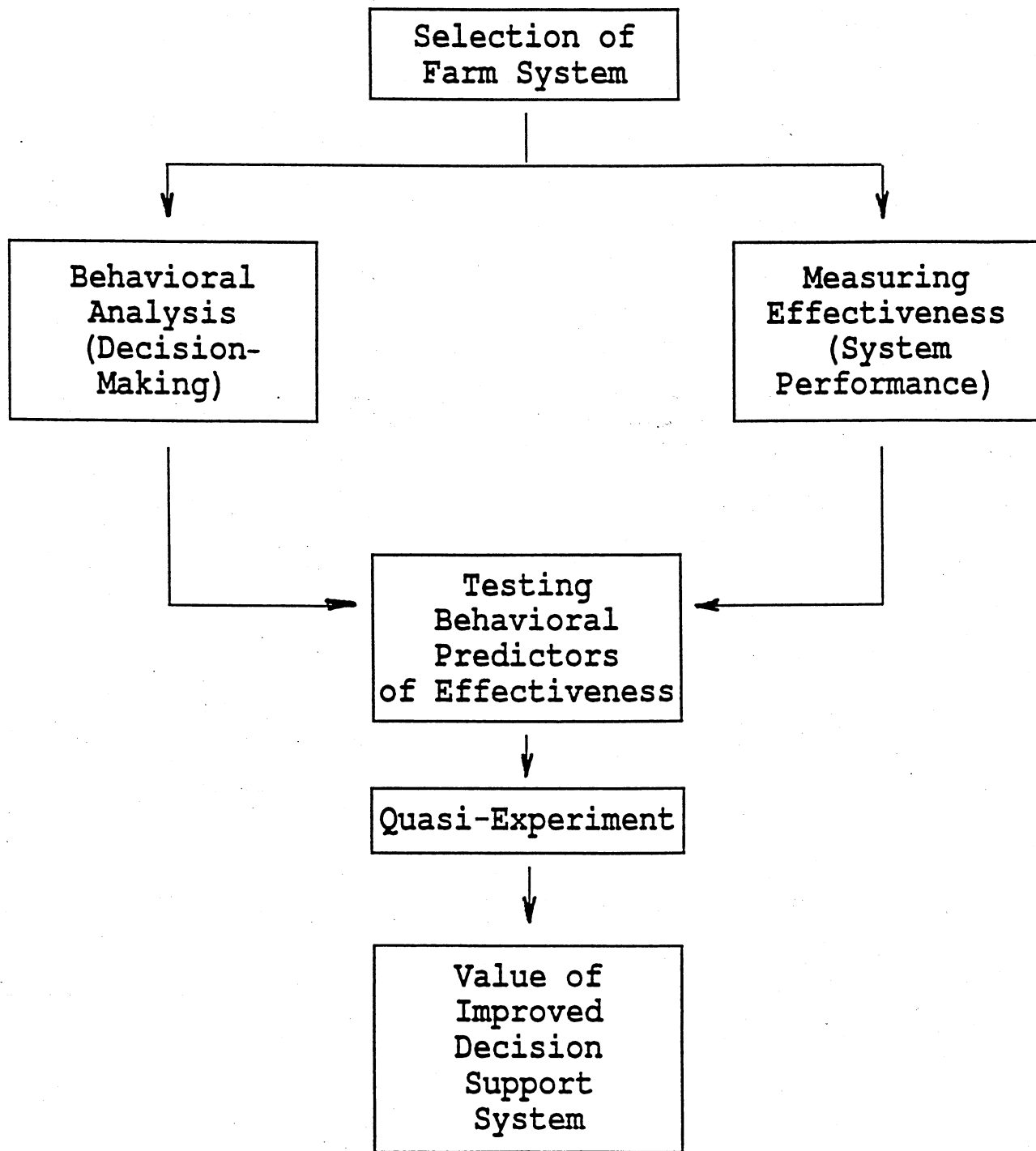


Figure 1:
Management Systems Research Model
for Measuring the Value of Decision Aids

analysis can be accomplished by cross-sectional analysis or comparisons over time. An approach combining both cross-sectional analysis among farmers and observation of the same farmers over time could help to isolate the real effects of information.

The first step in this phase is the selection of participants. To a great extent the farmers who use computerized decision aids must be self-selective since participation will require considerable commitment of time and effort over an extended period.

The mode of delivery of the technology also plays an important role. Computers are expensive in both physical and human capital terms. Therefore, one would expect that few farmers of any given type have access to computers. While one may find a few larger farms with computers, to obtain a sample of smaller farmers one would have to introduce the computer to them and train them in its use.

Fortunately, the North Carolina Agricultural Extension Service has placed computers in all of its 100 county offices. Additionally, in North Carolina there is a program to provide management assistance to small and limited-resource farmers. This is the Farm Opportunities Program administered by North Carolina A&T State University. In this program paraprofessionals work intensively with small groups of farmers over a three- to four-year period. When this research project was first implemented, the FOP was active in 15 counties across the entire state. The quasi-experiment was designed around this base of resources.

Development of computerized decision aids

Because the managerial function is complex, the decision aids developed or selected should aid managers in their most vital functions. The manager's role can be described as planning, monitoring, and control. Planning includes making decisions about what should be done both in the long run and in the short run. Monitoring includes observing the outputs of the farm system to see how well the actual results correspond to intended results. Control includes making decisions to alter the observed course or stay on course based on the monitoring process and evaluation of system performance.

The system developed or selected must satisfy the functional needs of the manager, and must be affordable and readily available. Unfortunately, such a combination did not exist at the inception of this project. Very good planning modules were available. One was FINPACK, which was developed at the University of Minnesota and which included both a one-year model and a five-year model. However, FINPACK was expensive. And it could not be duplicated for use in each of the five counties, nor could it become the personal property of the participating farmers. Some very good farm record-keeping programs also were available. But the record-keeping models did not "talk" to planning models. That feature is needed in the monitoring phase of management. The need to produce an inexpensive integrated planning and records management system soon became apparent.

The INTEG system

The result of evaluating the needs of small-scale farmers in terms of planning, monitoring, and control was A&T's development of the INTEG System. INTEG is an integrated set of decision aids in the form of Multiplan templates. The spreadsheet format was chosen because spreadsheets offer flexibility. This is especially important in light of the end users' need for interreaction so that they can produce a useful product. Multiplan was chosen as the electronic spreadsheet because it was available in all 100 extension offices, and because it allows for automatic data transferral between modules.

Figure 2 below describes the major components of the INTEG system of integrated Multiplan templates or modules. They are:

1. DATA, a data entry spreadsheet for the development of the structure of the farm operation includes resource constraints, input/output relationships, and expected prices.

2. LIVPLAN, which simulates financial results for a farm for one year by showing changes in assets, liabilities, earnings, and cash.

3. LONGPLAN, which projects the financial analysis factors of the farm plan developed in LIVPLAN over a six-year horizon.

4. COSTPR, which records bi-monthly expenses and receipts for each farm enterprise, along with overhead expenses and family income and expenditures.

5. MONITOR, which compares

projected cash flow and income developed in LIVPLAN with actual levels derived from farm operations and recorded in COSTPR.

6. MYBUDGETS, which determines the actual cost of production for each crop and livestock enterprise, and which analyzes physical efficiency rates and inventory changes.

The planning stage has three major components: DATA, LIVPLAN, and LONGPLAN. LIVPLAN, the heart of the system, is designed to compare alternative plans within the real-world constraints of the farm operator. Outputs of the model allow planners and lenders to compare cash flows, income statements, net worth statements and financial analysis factors of alternative plans. The financial analysis factors include net cash flow, net farm income, change in net worth, net farm income per acre, net farm income per hour, returns to assets, management income per acre, production value per acre, debt ratios, and cost ratios.

A set of 47 alternative crop budgets and 10 livestock budgets is stored on disk to facilitate planning. The budgets are based on average North Carolina input and yield conditions, but can easily be modified to suit specific conditions on an individual farm.

After the initial one-year planning stage, LONGPLAN is loaded. This will automatically take information formed by the LIVPLAN model and project the results of this plan over another five years. Although the planning models allow for only 10 crops and one livestock operation to be processed at a time, an auxiliary program - COMBINEP - allows for extension of the planning phase to as many crop and livestock operations

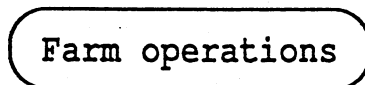
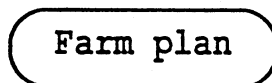
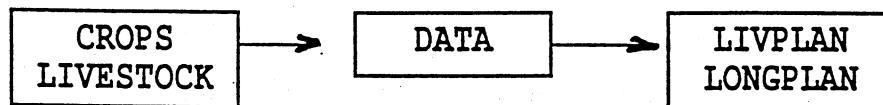
The INTEG System

PLANNING:

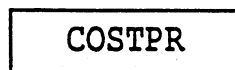
Data banks

Structure

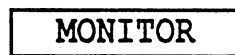
Planning
modules



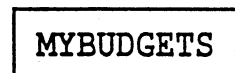
RECORD KEEPING:



MONITORING:



COST CONTROL:



END-OF-YEAR STATEMENTS:

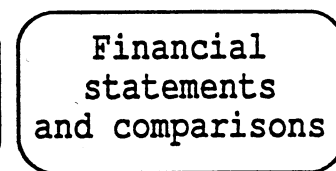
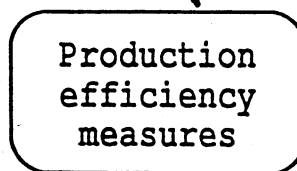
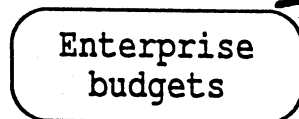


Figure 2:
The INTEG System Components

as the planner desires.

Farmers can use COSTPR, MONITOR, and MYBUDGETS to store and analyze data from actual farm operations during the year. COSTPR allows for the recording of monetary transactions, physical input utilization, labor utilization and crop and livestock inventory changes.

Information from the planning stage and from COSTPR is shared internally with MONITOR, which produces "to-date" financial statements along with comparisons of planned vs. actual levels of financial activities. Information from COSTPR also is shared with MYBUDGETS, which produces yearly enterprise budgets for each crop and livestock operation. These budgets can then be used to analyze the performance of the current year and to plan for subsequent years.

Description of participating farmers

The basic selection process began with paraprofessionals in each of the 15 counties in A&T's Farm Opportunities Program. Paraprofessionals in five counties - Pamlico on the coast, Vance in the northeast, Cumberland in the southeast, Caswell in the North Piedmont, and Yancey in the mountains - agreed to participate in the program. The paraprofessionals then solicited volunteers from among their Farm Opportunity Program participants.

The experiment includes not only observation but also interven-

tion, since farm participants must be trained in use of the computer. In the first year of the program, A&T personnel put the information given by farmers into the computer and trained farmers to use outputs of the planning and records management programs to make management decisions. In the second year a farm family member begins to enter farm data in the computer and develop outputs, with help from A&T personnel. By the end of the three- to four-year period, each farm family will have its own set of programs, which they can use on extension computers in their own counties. Thirteen farm operators participated in the study during the first year. (See Table 1.) The majority of operators (66 percent) were between the ages of 30 and 45 years, with an average age of 40.5 years. The spouses were approximately the same age as the farmers, 39.8 years, with 1.4 dependents.

The average farm operation consisted of 85.5 acres of owned land and 40.5 acres of rented land. Eighty-five percent of the operators produced an average of 6.6 acres of tobacco, with average projected sales of about \$25,376 per farm. Sixty-nine percent produced an average of four acres of fresh vegetables, with average expected sales of \$7,471. Forty-six percent grew an average of 25.2 acres of corn, with average expected sales of \$4,294.6. Five (38.5 percent) of the operators grew Christmas trees.

Almost all of the farm families (92.9 percent) supplemented their farm income with off-farm employment. The average off-farm income expected by the household was \$10,642.

Cost vs. benefits

Although the costs and benefits of the computerized decision aids cannot be definitely quantified until after three or more years of actual work with the farmers, some preliminary costs and benefits can be reported. The primary cost of the system will be the opportunity cost of the operator's time, since the computer and software are provided through the project.

However, if a farmer were to buy a computer system and the necessary software packages, the computer (a 384k IBM compatible) would cost \$1,600, the printer would cost \$300, the Multiplan software would cost \$295, and the INTEG system software would cost \$75, for a total cost of \$2,270. If the computer system is viewed as a depreciable asset with seven years of useful life, the yearly expense would be about \$335. However, for farmers participating in the program, the use of both the computer and software is free at present.

In terms of the opportunity cost for the operator's time, we estimate that planning will require two hours per farm (for 10 crops and one livestock operation) when planning is done by an experienced user. However, the training process necessary for a beginner is expected to take as much as eight hours, and the planning process another five hours. At \$5 an hour the opportunity cost should be at least \$65 per farmer. The bi-monthly data entry operation took from one to two hours per farm when done with an experienced user in conjunction with the farmer. It probably would take at least four hours per farm every two months when

done by the farm household. Therefore, the opportunity cost of the farm families' time, planning, and record-keeping could be as much as \$185 per year.

Benefits, of course, are more difficult to assess. As described earlier, a number of approaches can be used to estimate the benefits of an improved information system. One would expect the major benefits of computer use would be increased profits to the farm and/or time savings.

Development of a proper control group for comparison is problematic due to incompatibility of data. For instance, Mu'min (1987) in his Ph.D. thesis proposed management income per acre as a reliable and objective measure of managerial effectiveness. However, it is hard to use a measure such as management income per acre for purposes of comparison because of the data required to formulate management income. This requires net farm income, total assets and liabilities, plus operator and family labor utilization, and acres farmed. Although this information is an essential part of the information developed and used in the computerized system, for comparative purposes one would need to obtain this same type of information from the control group.

When the project began we thought records kept for participants in the Farm Opportunities Program would be adequate for such measurements. However, when we investigated the actual data obtained from these farmers, we discovered that not even the farmers' reported net farm income could be relied upon, and information on assets, debts, and use of labor was not available.

To our knowledge no available

secondary sources give this information on a yearly basis. Not even the census of agriculture, published once every ten years, collects information on family labor, nor are the census definitions of income and expenses necessarily compatible with IRS definitions. From experience with questionnaires, farmers either don't have, or are not willing to give, such detailed information on their farm operations.

From our mountain participants a possible group for comparison would be the participants in TVA's Rapid Adjustment Program. In this case at least, net income data for a set of farms has been kept over an extended period. However, this program is limited to mountain counties. Such detailed farm-level information is not available for farmers in the piedmont and coastal plains.

In determining how much time the farmers saved we are presented with another problem. Before we began field work on the project we thought we could determine how much time the participating farmers saved in their planning and record-keeping functions. However, for most of the farmers systematic planning and record keeping were new functions. Consequently, there was no realistic base for comparisons.

Because of the difficulties described above, the method used here can be called direct observation of incidences of monetary benefits. In other words, we tried to capture specific incidences in which we can be reasonably sure that the Decision Support System made a monetary difference in the farm operation. A number of such incidences can be described. Here are some examples.

Example 1: One of our farmers,

after viewing the outputs of his plan, decided to obtain off-farm employment. The initial plan showed that he needed to borrow \$6,000 in operating capital. But the plan also showed that he would have sufficient down time in his farming operations to allow him to seek part-time employment. By doing so, the farm family not only was able to increase earnings, but eliminated the need to borrow.

Example 2: One farmer who maintained a prolific number of enterprises was able to catch a \$6,000 bank error when his actual cash flow was found to be \$6,000 in the red. This farm handles 20 different crop enterprises and one livestock enterprise, which of course presents a major control problem. The oversight at the bank was not caught for more than six months.

When the workers hired to help with selling forgot to complete their end-of-the-week summaries, the oversight was caught by the computer system when actual sales fell far below projected sales. This amounted to a difference of more than \$8,000 in unrecorded sales.

During the planning process the model also was able to demonstrate to a farmer that he was receiving only \$1 of income for each hour of labor he invested in his cow/calf operation. This prompted him to sell part of the herd to reduce his outstanding debt, a debt that had caused serious liquidity and solvency problems for the farm. The induced sales amounted to an additional \$2,000, which could be counted against his borrowing needs.

Example 3: Another participating farmer planned to buy a new small tractor for his farm at ap-

proximately \$8,000. His main crop was Christmas trees, which would not have produced income for another three years. After assessing his cash flow needs for the next three years he decided instead to buy a used tractor for \$2,700. That improved his cash flow situation by more than \$5,000 over the next four years, or by \$1,300 each year.

Example 4: The Farmers Home Administration asked one participant to provide an estimate of his income for the 1987 crop year. We had been putting the farmer's actual expense and income figures in on a bi-monthly basis, with the farmer also keeping records in his usual manner at home. When he figured his expenses from his records at home and brought his statement to us to review, we discovered that according to the computerized records he was \$3,000 short on his expenses. If the farmer had not included these expenses on his tax records, he could have been taxed on that extra \$3,000.

By making some assumptions concerning measurement of cost and benefits, one can calculate an estimated net benefit of the DSS after its first year. The total opportunity cost of the farm operator's labor for participating farmers can be estimated at about \$185 each, or \$2,405 for the 13 farms. Based on just these four anecdotal examples, the combined value in terms of reduced expenditures, different resource allocations, and improved money management amounted to \$26,300 in before-tax benefits. This is an average gross benefit of \$2,023 per farm participant for just the first year. If we then subtract the two components of cost - \$335 for yearly computer expense and \$185 for opportunity cost of farm family time - the net benefit is about \$1,503 per farm

family for those who buy their own computer and about \$1,800 for farmers using the computers in the extension office.

Another way of interpreting the monetary benefits is to put them in terms of returns per hour of farm operator labor. We estimate that it would take each farm manager in our program about 37 hours per year to do his planning and records management using the INTEG system. If we take the average gross benefit of \$2,023 and divide it by 37 hours, then each farm operator receives \$54.67 for each hour spent in financial planning and records management.

Summary

The first two years of the project has produced a set of computerized decision aids (INTEG) for small-scale farmers and preliminary estimates of the net benefits of the system. Of course, only one year and 13 farmers do not provide enough information to lend any statistical significance to the \$1,500 or \$1,800 figure obtained here. However, one can conclude that even small-scale farmers such as those described here may benefit from using computers to help in the financial management of their farms. Farmers benefited by better use of family labor, better cost management, and reduction in errors in income and expense records.

Table 1
Characteristics of Farm Operators Participating in Study

<u>Description</u>	<u>Unit</u>	<u>1987 Crop Year</u>
Participants	Number	13
Age of operator	Years	40.5
Age of spouse	Years	39.8
Dependents	Number	1.4
Land owned	Acres	85.5
Land rented	Acres	40.5 (38.5%)*
Off-farm income	Dollars	\$10,642 (92.9%)
<u>Farm enterprises:</u>		
Tobacco	Acres	6.6 (84.6%)
Fresh vegetables	Acres	4.0 (69.2%)
Christmas trees	Acres	4.0 (38.5%)
Corn	Acres	25.2 (46.2%)
Soybeans	Acres	98.0 (30.8%)
<u>Crop budget projections:</u>		
Tobacco	Dollars	25,376.73
Fresh vegetables	Dollars	7,471.20
Christmas trees (one farm sales)	Dollars	3,332.00
Corn	Dollars	4,294.36
Soybeans	Dollars	11,579.95

* Numbers in parentheses represent the percentage of participating operators who produce that commodity.

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