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FARM OPERATION CHARACTERISTICS, INSTITUTIONAL SUPPORT, AND THE USE OF SOIL AND WATER CONSERVATION TECHNOLOGIES[1]

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ABSTRACT Technologies to control the severity of soil erosion and water pollution are available, and a large institutional structure supports soil conservation work, but success has been rather limited. This study of a sample of farmers in the three watersheds in central Iowa tests a number of hypotheses about the use of conservation technology. Institutional support factors were found to have a stronger relationship to the use of conservation practices than farm operation characteristics. The erosion potential of the land was conditional for specific conservation practice utilization. The use of institutional resources was positively related to farm size and scale. Thus institutional supports seem to be going to larger farms where the need for conservation practices seems to be greatest, but may not be adequate to encourage the full extent of conservation practices required on the totality of farms.

Introduction

Soil erosion is a serious problem in the United States. It is a problem not only to the farmer to whom the loss of topsoil means lower profit because of loss of the soils' natural fertility, but also to society. The problem to society comes through sedimentation in ditches, streams, lakes, reservoirs, and other bodies of water and the pollution of these waters through pollutants carried in the sediment. The cost of cleaning up the sediment and other pollutants amounts to millions of dollars annually.

Technologies to control the severity of soil erosion and water pollution are available. They exist in the form of various kinds of conservation structures and practices that farmers can use in their farming operations. Their potential benefit, however, is realized only when they are actually implemented. Unfortunately, there has been only marginal success in their implementation, despite nearly half a century of soil conservation programs by federal, state, and private organizations that provide educational programs and monetary and technical assistance.

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Why has success in soil conservation programs been so limited when such a large institutional structure supports soil conservation work? One suggestion is that the soil conservation programs do not reach the farmers who have the greatest need. That is, the farmers who make use of the programs are farmers with larger operations and more resources available for conservation work (Korsching et al., 1983; Hoover and Wiitala, 1980; Carlson et al., 1980; Choi and Coughenour, 1979). They are also farmers who operate better and less erosive land; thus, their overall cost for reducing erosion is less (Pierce, 1978). In other words, by providing the resources to the farmers who need assistance the least--those with larger farms, greater availability of resources, and less erosive land--the overall impact of the current soil conservation programs may be greatly diluted.

To improve the efficacy of soil and water conservation programs, we need a better understanding of the interrelationships among the factors of farm size and scale, erosivity of the land, and use of institutional support for controlling erosion. To that end, this paper examines 1) the relative impacts of farm size and scale characteristics and institutional support factors upon farmer use of conservation practices, 2) the relationship between farm size and scale characteristics and institutional support, and 3) the relationship between farm size and scale characteristics and erosivity of the land.

Institutional support for conservation

Soil and water conservation programs are basically programs of planned social change. Zaltman and Duncan (1977) suggest that four components must be present within the target audience for a planned social change program to be successful. There must be 1) an awareness of the problem and an awareness that a solution exists, 2) a felt need by the audience to solve the problem, 3) a commitment or willingness to allocate resources to solve the problem, and finally 4) the capacity to make the solution a reality.

The current programs of conservation agencies are intended to ensure that these four components exist within the target audiences. The Cooperative Extension Service (CES) conducts educational programs to create awareness of soil erosion problems and of the latest technologies for controlling soil erosion. Concomitant with the creation of awareness is an effort to create a need for solving the problem and a willingness to allocate resources--usually money and time--to implement the solution.

The Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) also conduct educational programs. Their primary role, however, is to enable farmers to implement the solutions. The SCS provides technical assistance in planning and implementing conservation technology on the farm, usually by developing a plan outlining the structures and practices necessary to reduce erosion to an acceptable level and by providing information on how to use the practices. The ASCS provides financial assistance through sharing the cost of

the various structures and practices. Other agencies may also become involved in providing financial assistance through cost sharing or providing low-interest loans.

Theoretically, the consolidated efforts of these organizations should combine all the elements necessary to produce the desired results. Yet many contend that the overall impact of soil erosion programs has been negligible (Barlow, 1979). The existing program is largely voluntary, with a reactive rather than proactive approach. Even today, however, the SCS maintains faith in the voluntary approach that farmers prefer (Korsching and Nowak, 1982). The SCS is allocating additional resources to develop more effective educational and technical assistance programs (Nowak, 1983; Korsching, 1983).

Farm size and scale and institutional support

Despite improved delivery of educational programs and technical assistance, there are those who contend that the basic problem will not be solved. The ability to obtain and use the assistance available from soil conservation organizations depends on the level of the farmer's existing capacity and the nature of federal policies. In terms of the level of existing capacity, agencies working in soil conservation have traditionally used a reactive approach. They assist the "walk-in" trade rather than actively soliciting those who have the greatest need from the standpoint of erosion problems and resources to solve those problems. Thus, these agencies are serving farmers with larger, more profitable operations with a greater existing capacity to control soil erosion.

SCS is attempting to improve this situation by increasing the allocation of resources to higher need, targeted areas. Part of the strategy is greater agency-initiated contact with the clientele. But the degree to which this will actually occur and to which farmers will be contacted remains to be seen. In terms of federal policy, Buttel (1980:462) contends that agricultural policies generally favor larger farmers over smaller farmers. Therefore, soil conservation programs within these policies would be more advantageous to large farmers.

What does all this mean to the viability of a voluntary approach to soil conservation? Although this paper cannot provide a definitive answer to that question, it can offer some insight into the nature of the assistance process and the factors influencing that process.

Although research generally has shown positive relationships between size and scale of farming operations and erosion control, results are inconsistent (Schertz and Wunderlich, 1981) with contentions that smaller farmers are more concerned about soil erosion and do more to control it (Geisler et al., 1981). This paper takes the analysis a step beyond the relationship between soil erosion control and size and scale of the farming operation by examining the need for conservation measures.

Ho. I: Use of conservation practices is positively related to size and scale of the farming operation.

Ho. II: Use of conservation practices is positively related to erosion potential of the land.

Ho. III: Erosion potential of the land is negatively related to size and scale of the farming operation.

Next, for a voluntary approach for controlling soil erosion to be effective, the institutional support must make an impact on erosion control activities.

Ho. IV: Use of conservation practices is positively related to use of institutional support.

Furthermore, to address the question of differential access to institutional support, the relationship between institutional support and size and scale of the farming operation is examined.

Ho. V: Use of institutional support is positively related to size and scale of the farming operation.

Finally, the relative impacts of size and scale of the farming operation, use of institutional support, and erosion potential of the land upon use of conservation practices are examined.

Data and methods

Data were collected as part of a study on the impact of best management practices (BMPs) on water quality. The study was interdisciplinary, with a sociological component to determine the social and institutional factors that influence the adoption and use of BMPs. The study area was three watersheds in central Iowa, and the sample included all farmers making management decisions on the land in the three watersheds (N = 193). The three watersheds were matched with each other on social and demographic characteristics of the farm population as well as geographic and agricultural characteristics such as topography, soil type, erosion potential, and dominant cropping patterns.

The study involved a series of contacts with respondents over a 2-year period. The initial contact, in February and March of 1980, involved personal interviews conducted by the Sample Survey Section of the Iowa State University Statistical Laboratory. Interviewers were instructed to make contact with every rural resident within the physical boundaries of the respective watersheds. A screening procedure allowed for the determination of

residents who did not operate farmland in the watersheds. It also allowed for an identification of persons who operated land surrounding a farmstead, but who did not reside on that farmstead.

The first questionnaire centered on obtaining demographic background information, measurement of relevant attitudes (e.g., agrarianism, environmentalism, risk preference, innovativeness), organizational affiliation, community orientation, and the use and perceptions of various soil, water, and energy conservation practices.

The second contact with respondents was made in the summer of 1980. This was a telephone survey conducted by interviewers from the Statistical Laboratory at Iowa State University. It focused on farm firm characteristics, including size of the farm operation, organizational type, tenure, on-farm and off-farm labor, farm decision making, and the acceptability of conservation policy alternatives.

In March of 1981, the third contact, a personal interview, was made with respondents to obtain the necessary information to calculate the Universal Soil Loss Equation (USLE) (Troeh et al., 1980) for each field in the watersheds. This identified the field boundaries for all land operated by respondents who farmed any land in the watersheds. Detailed questions were asked regarding ownership status, cropping and rotations, use of implements, and average crop yields for each of the identified fields. As a result of attrition in the respondent population from relocation of operators, refusals, and other reasons, the N after the third contact was 153.

Relevant data for this paper include indicators of the use of soil conservation practices, indicators of characteristics of the farming operation, indicators of institutional support in using conservation practices, and some measurement of the need for soil conservation practices.

Soil conservation practice use

Use of soil conservation practices was measured with two indicators. The first, indicating the use of conservation tillage, was the average amount of crop residue per acre remaining on the farm at the time of spring planting. This was calculated on a per-field basis by using information in the USLE which allowed for an overall farm average of crop residue to be computed by weighting the amount of residue on individual fields by the relative number of acres of these fields in the total operation. Average values for the overall sample ranged from approximately 100 to nearly 4,000 pounds, with a mean of 836 pounds of residue per acre.

The second indicator was an index combining four practices other than reduced tillage. Respondents were assigned one point for each of the following practices that they had adopted--contour planting, strip cropping, sod waterways, and filter strips.

Farm operation characteristics

Three indicators of size and scale of the farming operation were included. Total acres in the farming operation was obtained by asking respondents the number of acres owned and operated, the number of acres cash rented, and the number of acres crop shared for their operation in the 1980 crop year. Farms ranged in size from 40 acres to 1,740 acres, with a mean of 451 acres. Average annual gross farm income was measured within specified categories over the 3-year period of 1977-79. Use of hired labor was measured by asking farmers to indicate the total number of days of full-time hired labor, days of part-time hired labor, and days of occasional hired labor used the previous year in their farming operations. The mean days of hired labor was 72.5 days.

In addition to these indicators on size and scale, previous research has identified two other farm operation characteristics related to the use of soil conservation practices. One is tenure, or the farmers legal status relative to the land operated (Hoover and Wiitala, 1980; Lee, 1980; Ervin, 1981). Owners are more likely than renters to use soil conservation practices because they are more likely to benefit directly from economic incentives for implementation and more likely to reap long-term benefits. Tenure was measured as the ratio of land owned to total acres in the operation. Scores ranged from zero (no land owned) to one (all land owned), with a mean of .47.

The second farm operation characteristic included is the business organization of the farm firm (Korsching et al., 1983). More complex forms of legal ownership reflect a greater commercial farming orientation that includes higher levels of managerial skills and a larger resource base. The business organization of the farm firm was assessed for its complexity, ranging from a single-family operation to a corporation of unrelated individuals. Of the sample, 76 percent were single-family operations, 11 percent were partnerships of unrelated individuals, 5 percent were single-family corporations, 2 percent were partnerships of unrelated individuals, and 6 percent were multifamily corporations.

Institutional support

The first institutional support factor is credit. Farmers were asked about their past use of credit to acquire such items as land, machinery, farm buildings, and livestock. Thirteen percent of the farmers did not rely on credit at all, 21 percent used it to a small degree, 31 percent used it moderately, and 35 percent used it to a large degree. To measure contact with soil conservation agencies, farmers were asked the number of times that they visited or talked with a member of the SCS, ASCS, or local Soil Conservation District Commission in the year preceding the interview. The total number of such visits was recorded for each respondent. The numbers ranged from 0 to 81 visits, with a mean of 8.6 visits.

Financial assistance from the ASCS for implementing soil conservation practices was included. It was measured as the proportion of practices for which cost-sharing funds were received. Practices included were contour planting, strip cropping, terracing, sod waterways, and filter strips. The mean proportion of cost-shared practices was .19. The final institutional factor is whether the respondent had a conservation plan prepared by the SCS and, on a scale from 1 to 4, the degree to which it was implemented. Of the farmers in the sample, 41 percent did not have a plan, 5 percent had a plan that had not been implemented at all, 39 percent had a partly implemented plan, and 15 percent had a fully implemented plan.

Need for soil conservation

Need for soil conservation was measured through use of the Universal Soil Loss Equation (USLE). The specific factors used were rainfall (R), soil erodibility (K), slope length (L), and slope gradient (S). This set of USLE factors, when taken together, indicates the erosion potential of land. An average for each farm was calculated by weighting the RKLS on each field by the number of acres in the field and dividing by the total number of acres in the operation. In interpreting the RKLS factor, the coefficient increases in size with an increase in the erosion potential of the land. The values for RKLS ranged between 7.3 and 156.1, with a mean of 39.5.

Analysis

Analysis begins with examining the effects of farm operation characteristics and institutional support factors on the use of conservation practices, Hypotheses I and IV. Table 1 shows that the correlations between institutional support factors and using conservation practices are larger and more consistent than correlations between farm operation characteristics and using conservation practices. Of the size and scale indicators, total acres operated is significantly related to the conservation practice index, and gross farm income is significantly related to crop residue. Only hired labor is significantly related to both crop residue and the conservation practice index. The magnitude of these relationships, however, is weak even though significant. Of the other farm operation characteristics, tenure is significantly related only to crop residue, and complexity of the business organization is not significantly related to either indicator of conservation practice use.

The institutional support factors, on the other hand, are all significantly related to the conservation practice use indicators except for the relationship between receiving cost-share funds and crop residue. Furthermore, of the remaining significant relationships, the only one that is weak is the relationship between agency contacts and the conservation practice index. The other correlations can be

Table 1. Zero-order correlations among farm operation characteristics, institutional support factors, land erosion potential, and conservation practice use

	1	2	3	4	5	6	7	8	9	10	11
Conservation practice use											
1. Crop residue											
2. Conservation practice index	.22										
Farm operation characteristics											
3. Total acres	.10	.16									
4. Tenure	.16*	.03	-.10								
5. Gross farm income	.17*	-.03	.64*	.04							
6. Farm organization type	.08	-.01	.46*	.10	.40*						
7. Hired labor	.15*	.15*	.44*	.02	.32*	.33*					
Institutional support											
8. Use of credit	.28*	.26*	.33*	-.06	.37*	.07	.18				
9. Agency contacts	.48*	.18*	.30*	.16*	.07	.01	.29*				
10. Cost share	.08	.35*	.05	.13	.16*	.25*	.26*	.12	.02		
11. Conservation plan	.24*	.29*	.19*	.05	.12	.00	.20*	.07	.18*	.08	
Need for conservation											
12. Erosion potential	.01	.25*	.22*	.27*	.14	.20*	.21*	.17*	.04	.15*	.12

*Significant at .05 level or greater. Ns vary from 140 to 193, depending on missing information.

considered moderate in magnitude, with one, the correlation between agency contacts and crop residue, a strong relationship (.48). Compared with farm operation characteristics, institutional support factors evidently have a stronger relationship with the use of conservation practices, thus providing support for Hypothesis IV but little support for Hypothesis I.

The next issues to examine are the relationships between use of conservation practices and the erosion potential of the land, Hypothesis II, and the relationship between size and scale of the farming operation and erosion potential of the land, Hypothesis III. Table 1 shows no relationship between erosion potential and the use of crop residue, but a moderate relationship (.25) between erosion potential and the conservation practice index. These results may be related to the specific nature of the two indicators of the dependent variable. Maintenance of surface crop residue potentially has universal application for row crops and is a recommended practice for fields of all gradients, whereas the specific practices constituting the conservation practice index are more appropriate for the steeper and longer slopes. Therefore, Hypothesis II is conditionally supported. Furthermore, the correlations between erosion potential of the land and size and scale of the farm operation and other operation characteristics are all positive, significant, and in the weak to moderate range except gross farm income. This finding raises questions about past assumptions that farms of larger size and scale were also farms with less erosion potential. The assumption is certainly not valid for this sample and opens the question relative to other geographic areas as well. Hypothesis III is not supported.

Finally, Hypothesis V stated that the use of institutional support is positively related to size and scale of the farming operation. The correlations indicate that there is a relationship between farm size and scale and use of institutional support. Two variables have an especially strong and consistent relationship with institutional support--total acres farmed and the amount of hired labor employed. Of the five indicators, total acres farmed and amount of hired labor employed are probably the best measures of size and scale of the farming operation. The significant relationships are all in a weak to moderate range and all in the expected direction.

These data support the contention that size and scale of the farming operation are positively related to access to institutional resources. In other words, farmers with larger operations receive more institutional support. This must be placed in the context of the findings for Hypothesis III, however, that the larger operations also have land with higher erosion potential.

Regression analysis

The results indicate that the two measures of use of conservation practices are significantly and more

consistently related to the institutional support factors than to the measures of farm size and scale and that only the conservation practices index is significantly related to erosion potential of the land. The independent variables are now regressed upon each of the measures of conservation practice use to determine their relative effects and overall predictive power. Stepwise forward selection multiple regression is used. Erosion potential of the land is entered first because this is a predetermined factor over which the farmer has no control. It is the various conservation structures or practices that ameliorate the potential for erosion. The other variables are entered according to the F-ratio at each step. Tables 2 and 3 are the regressions for crop residue and the conservation practice index, respectively.

Tables 1 and 2 indicate that both regressions are significant at the .001 level. The tables also indicate that there are some differences in the relative importance of specific variables that predict each of the two measurements of soil conservation practice use. As already suggested by the correlations, erosion potential is an important factor for the practices included in the conservation practice index but not for crop residue. Erosion potential explained 6 percent of the variation in the conservation practice index, but it explained no variation for use of crop residue. In fact, erosion potential did not enter the regression for crop residue until the third step, although it had received a higher priority than the other variables. This is a function of the program used, the Statistical Package for Social Sciences (SPSS). If a variable's F-ratio does not meet the minimum qualifications, it may enter under a lower priority or not at all (Nie et al., 1975:346). As suggested, the lack of importance of erosion potential for the use of crop residue may be a function of its nearly universal potential for application to row crops on fields of all gradients.

Although there is not complete consistency across the two regressions of specific variables that predict the use of soil conservation practices, the institutional variables are more important than the farm operation characteristics in both regressions. For the conservation practice index, most of the explained variation (18 percent) comes from three variables--erosion potential, conservation plan, and use of credit, although use of credit is not significant (it falls just beyond significance at the .05 level). Another institutional factor, cost sharing, adds an additional 1 percent, and only 2 percent more is explained by farm size and scale factors. For crop residue, most of the explained variation (18 percent) is a result of the first four variables, three of which are institutional support factors. Hired labor, total acres, gross farm income, and tenure each contribute an additional 1 percent, although none are significant.

Examination of specific institutional support factors shows that having a conservation plan is an important predictor for the conservation pratice index and crop residue. Use of credit also seems important to both,

Table 2. Regression of farm operation characteristics, institutional support factors, and erosion potential on crop residue

	Beta	R^2	R^2 Change	F
Use of credit	.26	.08	.08	8.45*
Agency contacts	.32	.15	.07	11.05*
Erosion potential	.06	.15	.00	.52
Conservation plan	.20	.18	.03	4.94*
Hired labor	-.14	.19	.01	2.24
Total acres	-.20	.20	.01	2.70
Gross farm income	.13	.21	.01	1.21
Tenure	.07	.22	.01	.49
Farm organization type	.04	.22	.00	.18
Cost share	.04	.22	.00	.16

*F = 3.59. DF = 10,127. P < .001
*P < .05
N = 138

able 3. Regression of farm operation characteristics, institutional support factors, and erosion potential on conservation practice index

	Beta	R^2	R^2 Change	F
Erosion potential	.21	.06	.06	5.93*
Conservation plan	.24	.16	.10	7.37*
Use of credit	.17	.18	.02	3.59
Cost share	.12	.19	.01	1.84
Gross farm income	-.11	.20	.01	.85
Hired labor	.08	.21	.01	.87
Total acres	.06	.21	.00	.26
Farm organization type	-.04	.21	.00	.21
Tenure	-.02	.21	.00	.03
Agency contacts	-.01	.21	.00	.01

F = 3.43. DF = 10,129. P < .001
*P < .05
N = 140

although this did not achieve significance for the conservation practice index. Number of agency contacts was a strong factor for crop residue but not significant for the conservation practice index (it entered last in the regression). This may be a function of the higher level of managerial skills needed for successfully using the various minimum- and no-tillage practices. Having received cost-sharing funds was not a significant predictor for either indicator of the dependent variable, but the practices in these two indicators do not require the large investment necessary with some of the structural practices such as terraces.

Discussion

In summary, the results show that institutional factors have a stronger link to the use of soil conservation practices than do farm operation characteristics and that the influence of the erosion potential of the land is conditional on the specific conservation practice. In turn, the use of institutional resources is positively related to farm operation characteristics of size and scale. A surprising finding is that the larger farms in size and scale are not necessarily the farms with the best, least erosive land.

These results support the SCS and other soil conservation agencies that prefer to use, and hope to maintain, the voluntary approach to soil conservation. To maintain the voluntary approach, the resources that these agencies have at their disposal should be channeled in the direction of the more severe problems rather than to areas of minor problems. The data show that, in this sample, the institutional resources for ameliorating the problem do have a tendency to flow to the farms with more erosive land. Therefore, from the standpoint of erosion control, the resources are correctly allocated to the farms with need, even though they may be going to the larger farms. The results, however, should be considered tentative and used as the basis for further research. The distribution of the quality of land among farms of various size and scale may be different in other regions of the United States. Furthermore, the research does not provide any indication of the quality of land and allocation of financial resources in this watershed in comparison with other watersheds. In other words, it does not explain the relationship between need and the allocation of resources on a broader scale.

The question of need, of course, raises another issue. There are really two kinds of need at stake. Given two farmers with different levels of erosion on their respective operations, the farmer with the smaller operation and less serious erosion problem may find it more difficult financially to control the problem that the farmer with the larger operation with a more serious erosion problem. A decision on allocation of resources for the first need, to obtain the most conservation for the dollar, is an economically rational decision. A decision on allocation of

resources for the second need, the relative financial need of each farmer, is a normative decision that has no objective criterion. Some questions involve issues of individual and societal responsibility and obligations for maintaining the soil base for agriculture and the productive capacity for producing food and fiber for the nation.

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