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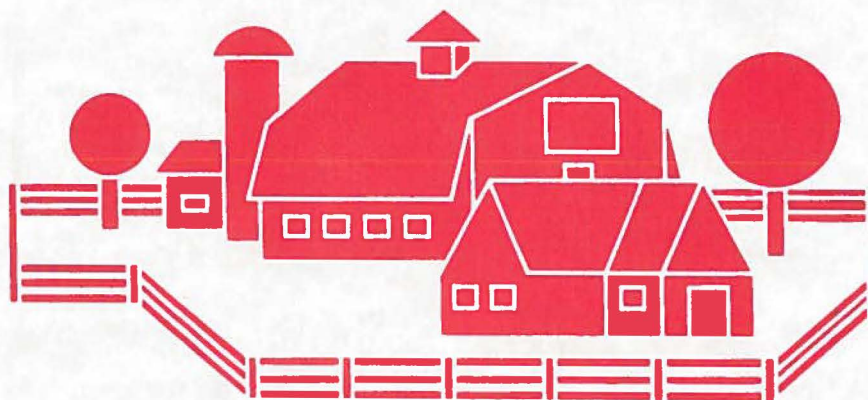
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**FARM MANAGEMENT
EXTENSION WORKSHOP**

FARM MANAGEMENT: CHALLENGES AND RESPONSIBILITIES FOR A NEW AGE



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FARM INFORMATION SYSTEMS:
NEEDS, METHODS, AND RESPONSIBILITIES

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Significant advances in information technology in recent years have dramatically reduced technical and economic barriers to the provision of information systems and information services to farm managers. At the same time, increased commodity market instability, more complex crop and livestock production technologies and an economic environment that makes financial planning and control more important than ever before have increased farmers' demand for information. Despite these changes on both the supply and demand sides of the market place for information related products and services, however, the adoption rate of computer based farm information systems has been much slower than expected. The optimism of just a few years ago has, for some, been replaced by a sense of frustration and by growing uncertainty about the direction of farm information systems development.

A number of factors have contributed to this situation. First, the extraordinarily rapid rate of technological change in information technology has, itself, discouraged some farmers from investing in new information systems. New hardware and software products quickly become obsolete, and the costs of modifying an existing information system or of converting to a new one are considerable. In addition, widespread financial stress in the sector has reduced levels of investment in general, and this has slowed the adoption of products and services based on information technology. Perhaps the greatest impediment to adoption, however, has been the fact the farm information systems and information services often do not meet the needs of farm managers. This problem is not unique to farm firms. One of the most difficult challenges for any information system developer is to design and implement systems that support the activities of general managers.

In this paper I define, in a broad sense, the general requirements for a farm information system. I then discuss the applicability of two major areas of information systems research--data resource management and decision support system design--for designing farm information systems that are more effective from a managerial perspective. In the final section of the paper, I discuss the role of extension in designing, developing, and implementing farm information systems. The design of educational and applied research programs related to information technology based products and services, the role of extension as an information provider, and extension's relationship to the emerging information industry serving agriculture are the major areas of focus for this discussion.

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General Farm Information System Requirements

Davis and Olson (p. 6) define a management information system (MIS) as:

...an integrated, user-machine system for providing information to support operations, management, and decision making functions in an organization. The system utilizes computer hardware and software; manual procedures; models for analysis, planning, control and decision making; and a database.

This definition serves as a useful starting point for a discussion of the uses and users of a farm MIS. It also raises important questions about assumptions regarding the physical structure of such a system. In this section, these issues related to general farm information requirements are discussed.

An MIS serves three broad functions in a farm operation. First, it is a mechanism for collecting, organizing, storing, and retrieving data about the firm and its environment. Data is an essential resource for decision making, and an effective MIS helps create, manage, and maintain that resource to support a broad range of operational and managerial activities. Second, through the generation of standard reports and support of ad hoc queries, an MIS serves as a medium for communication both within and outside of the farm firm. Financial statements prepared for lenders are a familiar example of standard reports that support communication outside the firm. As the organizational structures of farm operations become more complex, the support of internal communications by MIS will become increasingly important. In large, multi-family operations, for example, specialized managerial roles may follow the traditional functional lines of production, marketing, and finance. A major benefit of specialization is lost if all information is shared among the managers in charge of these functional areas. On the other hand, serious coordination problems may arise if no information is shared. A well designed MIS can serve as both a channel and a filter for information flows across functional units. Finally, from a managerial perspective, the support of analysis for problem recognition, planning, and control is perhaps the most important function of a farm MIS. A well designed MIS should provide a flexible, easily used set of models and data resources that managers can use to identify problems and explore the consequences of alternative solutions.

The users of a farm MIS are best identified by their functional roles. It must be recognized, though, that individuals typically have several roles in a farm operation, and a single person may be in several user categories. People acting in managerial roles are, of course, key users of a farm MIS. It would be a serious mistake to limit the relevant set of users to managers, however. People doing the clerical work of keeping financial and production records and those who perform day-to-day crop and livestock production operations may be much more frequent users and may find their work supported more effectively by a farm MIS. Finally, consultants working for farm operations are another potentially important set of MIS users. As production technology and management alternatives become more complex, consultants will be used more frequently by farmers, and a well designed MIS can be a valuable source of firm specific data to support consultants' activities.

Regarding the physical structure of a farm MIS, Davis and Olson's definition requires that an MIS be at least partly computer-based. They also recognize the importance of manual procedures, however. A key question in the design of farm MIS is, of course, the degree to which they are computerized and the necessity of having computer hardware on the farm. In the discussion here, farm MIS are limited to information systems that have at least some computer based components, but no assumptions are made about the location of the computer hardware. Many of the design issues considered here are, however, most relevant for operations with some on-farm computing capability. This seems appropriate, since the decision to invest in an on-farm computer is driven primarily by the degree to which available systems are designed to meet user needs.

In closing this discussion of general requirements for a farm MIS, it is important to note the emphasis Davis and Olson give to integration in their definition. An MIS is a collection of hardware, software, models, procedures, and data, but the usefulness of these components depends largely on the degree to which they fit together into an integrated system. Total integration is rarely possible and is almost never economically justifiable. Advances in hardware and software are making it easier to achieve relatively high levels of integration, though, and this is an important design objective that should be kept in mind as database requirements and applications development are examined in greater detail.

Data Resource Management

Data about the firm and its environment is essential for effective support of managerial activities, and some of the most significant recent advances in information technology have been in the areas of data storage, data communications, and database management systems. Despite this technological progress, however, the effective management of data resources continues to be a difficult problem in the design and implementation of farm information systems. In this section, the potential for recent advances in the area of data resource management to have a positive impact on farm MIS design is explored. Because the problems associated with the management of firm specific data and data about the firm's environment are quite different, these issues are discussed separately.

Focusing first on data about the farm firm, the high costs of data collection and data entry are a major source of problems. Data collection and entry are time consuming, and the range and volume of data needs does not usually increase proportionately with the size of the operation. There are, then, important scale economies in the acquisition of firm specific data that are difficult for small farm firms to capture. As a result, smaller firms often limit the scope of the data collected to that required for the preparation of financial statements and tax returns. Enterprise specific financial data may be viewed as too expensive to collect and enter. Production data is even less likely to be collected and maintained. The result is a limited data resource base that makes it difficult to effectively use the managerial support provided by a well designed MIS.

Some encouraging progress is being made in data capture technology, however. With regard to financial data, check writing capabilities are being included in more farm accounting software packages, so that financial records can be updated automatically as transactions are made. In addition, more commercial banks are offering financial record services that record financial data as checks are

processed. With regard to production data, automated data sensing and recording devices are being developed for a wide range of intensive crop and livestock production processes. Voice data entry technology is also becoming more operational. These are, for the most part, solutions to the data capture problem that require a high fixed investment. While they may have the potential to lower data entry costs for nearly all operations, they are most likely to be adopted by large firms.

A second, and perhaps more difficult, problem associated with the management of firm specific data resources is that of organizing the data so that it can be used easily. In most farm MIS, data are organized in application dependent form. For example, the data files created by many farm record systems are organized to support the efficient generation of financial statements and enterprise analyses. They are not organized to support ad hoc queries or to serve as a data resource for other application programs. The primary design objective is to maximize the efficiency of a single application.

An alternative approach to organizing firm specific data is to treat it as a separately managed resource. This approach--commonly called the database approach--has been made possible by advances in disk storage technology, data modeling concepts, database management software, and procedures for determining database requirements. Design objectives under this approach, as identified by Everest (1985), are: availability, shareability, evolvability, data independence, and data integrity. These are briefly defined in Table 1. When they are met, the result is a data resource that can efficiently meet anticipated needs and can be modified to meet unanticipated future needs without necessitating major changes in other components of the MIS.

Table 1. Design Objectives Under The Database Approach

<u>Database Objective</u>	<u>Description</u>
Availability	Data should be available for use by applications (both current and future) and by queries.
Shareability	Data items prepared by one application are available to all applications or queries. No data items are "owned" by an application.
Evolvability	The database can evolve as application usage and query needs evolve.
Data independence	The users of the database establish their view of the data and its structure without regard to the actual physical storage of the data.
Data integrity	The database establishes a uniform high level of accuracy and consistency. Validation rules are applied by the database management system.

Source: Management Information Systems - Conceptual Foundations, Structure, and Development, Second Edition, Gordon B. Davis and Margrethe H. Olson, p. 504.

From a conceptual standpoint, the database approach is clearly superior to application dependent schemes as a methodology for organizing firm specific data in a farm MIS. This approach requires a high level of technical expertise for database design, however. Because differences in farms imply differences in database structure as greater levels of detail are sought, it may be difficult to design broadly applicable database structures. A closer look at some of the methods developed to implement the database approach, however, suggests there may be some reason for optimism in this regard.

The first and perhaps most difficult step in the database approach is to determine the content of the database. Davis and Olson (p. 516) identify three general strategies for determining database content. First, it may be determined by identifying the data needs for all existing and planned applications programs in the overall MIS. This can, for example, be accomplished by constructing data flow diagrams (Yourdon and Constantine) that describe the flow of data processing and define the data required to accomplish it. A second approach is to base the determination of data requirements on a description of the organization rather than on a description of data processing applications. Davis and Olson call this an anticipatory strategy, because it is more likely to identify data required for future, as yet undefined needs. This approach is supported by graphic methods such as the entity-relationship diagrams developed by Chen. A third strategy is to simply start with existing file structures and modify them to meet new needs. This evolutionary approach has a lower initial cost, but it is based on the assumption that the existing database is relatively well structured. Regardless of the design strategy adopted, once the desired content of the database is determined, a database model--e.g. relational or hierarchical--is selected and the data are normalized (Date, pp. 237-272) to reduce redundancy and updating problems.

Faced with the problem of identifying database structures that are broadly applicable across farm firms, it is important to note the parallels between the anticipatory design approach and what is already done implicitly when commercial farm record software and service bureau systems are designed. In order to be successful, the developers of the systems must identify data needs shared by many farms. What they have not seen the need to do is organize the data their record systems collect so that data becomes an available, shareable resource.

Some private firms are beginning to take this next step and are designing record systems based on the database approach. In most, if not all cases, though, they have not revealed enough about the database structure of their systems to allow other software developers to design application programs that draw data from them. They do this in order to retain their competitive advantage on the record side, since a record system with these features should be more valuable to users. In addition, this gives users of their systems less incentive to buy applications software from other firms. While this is a valid competitive strategy, it may be less than optimal from a user and societal point of view. In the area of production records, Fuller has outlined a production control system based on database concepts. Several DHIA processing centers now offer or are considering development of on-line access capabilities that will allow producers to download data from their own records. This will benefit not only farmers, but will also give veterinarians and production consultants access to data resources that will allow them to offer a broader range of services more efficiently.

Finally, state farm record projects represent another opportunity to develop more effective database designs. In Minnesota, for example, farm management association data are being stored and processed in a relational database management system. Extension efforts such as this are likely to make a particularly important contribution because they make it possible for alternative database design structures to be openly examined and evaluated. Just as these farm record systems were, in the past, prototypes for commercially developed microcomputer and service bureau record systems, they can, in the future, be prototypes for record systems that create a manageable data resource. The development of such systems by the public sector will also make it easier for application software developers to design and prototype programs that will draw data from farm record databases. This is essential, since the cost of creating a manageable data resource can be justified only if it is used.

Turning briefly now to data resource management problems associated with data about the firm's environment, significant scale economies associated with data capture and database design, coupled with advances in telecommunications technology, are making the provision of on-line data services a potentially profitable business opportunity for a broad range of non-farm firms serving agriculture. A number of on-line systems that meet the design objectives of the database approach have been developed. As a result, the managers of farm operations often find data about their firm's environment easier to acquire than data about their own firms.

The major problem with these systems is not easy, flexible access to data. Rather, it is a lack of applications software that can readily accept data from these services. This problem can be attributed primarily to the newness of these systems, however, and should be short-lived. In the long term, the continuing problem is likely to be access to firm specific data to combine with environmental data in application programs designed to support a broad range of managerial activities.

Decision Support System Design

Data resources are useful only when placed in the context of particular decisions. This is the basis for the frequently made distinction between data and information. Following the discussion in Everest (1974, p. 164), data is simply a representation, often numeric, of facts or beliefs. Information, on the other hand, is data evaluated in relation to a particular problem or decision. This distinction is subtle and somewhat artificial, but it helps emphasize the importance of models as well as data resources in a farm MIS. One criticism of MIS in large organizations is that, with their emphasis on generating standard reports and channelling information flows, they do not help managers integrate data from a number of sources into the context of particular decisions. Therefore, they support managerial work only indirectly (Keen and Scott Morton, pp. 1-2). This criticism also holds for many farm MIS.

The concept of a decision support system (DSS) is, in part, a response to this problem. Sprague and Carlson (p.4) define DSS as "interactive computer-based systems that help decision makers use data and models to solve unstructured problems." This definition succinctly identifies four key characteristics of DSS. First, and most important, this definition emphasizes help or support for decision makers. A DSS is a tool to be used by decision makers rather than a substitute for them. This feature is the overriding consideration in the design

of DSS. Second, DSS are interactive---they are meant to be used directly by decision makers and, so, need to provide both quick and flexible response. Third, they contain and integrate both data and models. This means they give users easy access to data and to tools for combining and analyzing data from several sources. Finally, DSS are designed for use in unstructured decision situations. Often these are situations where computer based support can improve both the efficiency and effectiveness of decision making, but the need for human judgement makes automation of decisions undesirable or impossible.

Just as new approaches to data resource management have been made possible by advances in information technology, the design of DSS has been made more feasible by technological change. Particularly important have been developments in microcomputers---developments that have also made on-farm MIS economically feasible. In this section, the potential for advances in DSS design to have a positive impact on farm MIS design is explored.

The central question in DSS design is that of how decisions can be supported most effectively. A brief examination of the contrast between rational and behavioral models of decision making is a good place to begin a discussion of this issue. In its most extreme form, the rational model of decision making is based on the behavioral assumptions of static economic theory. Alternatives and their associated outcomes are assumed to be known completely, and decision makers are assumed to maximize known utility functions. Under these conditions, optimization methods are the logical and appropriate basis for decision making. The rational theory becomes more complex as these assumptions about knowledge of alternatives, outcomes, and preferences are relaxed---complexity that is evidenced in the growing farm management literature on decision making under uncertainty. The feature that remains unchanged, however, is an emphasis on how decisions should be made.

An emphasis on how decisions actually are made is the essential feature of behavioral models of decision making. Here, initial assumptions have a much different focus. At the basis of Simon and Newell's information processing model of human problem solving, for example, is the assumption that humans share four essential characteristics that are relevant for describing decision making behavior. First, people process information in serial rather than parallel fashion---i.e., they think about things one-at-a-time rather than simultaneously. Second, short term memory is quite limited. As Miller's classic results demonstrate, we can only keep seven, plus or minus two, bits of information in short term memory. Third, humans have essentially unlimited long term memory. Retrieval from long term memory is rapid, but the time required to "write" information to it is long. Finally, people can and do make use of external memory devices, such as scratch pads, books, and databases. Newell and Simon's early work focused on carefully chosen, structured tasks, such as chess problems and cryptarithmic puzzles. More recent work on behavioral models of decision making has applied their insights in more realistic settings. Articles by Einhorn and Hogarth and by March and Shapira provide good overviews of recent research in this area.

The challenge in DSS design is to draw on insights from both rational and behavioral decision theories in order to build tools that take advantage of the power of normative models and are well adapted to both the strengths and weaknesses of humans as problem solvers. An attempt to achieve such a synthesis is reflected in the following four basic DSS components identified by Carlson (p. 21) in his framework for DSS design:

1. Specific representations (e.g. graphs, tables, and pictures) to assist in conceptualization and to provide a frame of reference for using the DSS.
2. Operations on the representations to support intelligence, design, and choice activities in decision making.
3. Memory aids to support the use of representations and operations.
4. Control aids to help the decision maker control the representations, operations, and memory aids.

Representations, control aids, and memory aids such as computerized scratch pads and data files for storing the content of previous screens displayed in an analysis are all designed with insights drawn from behavioral theories of decision making in mind. On the other hand, operations such as stochastic budgeting models and statistical procedures, as well as memory aids such as internal and external databases, tend to be based on rational theories of decision making.

Further insights on how such a synthesis of ideas from rational and behavioral theories of decision making can be achieved and on how decision makers can be supported most effectively are likely to come from research in the area of expert systems. An expert system is a model of the reasoning processes an individual follows in solving particular classes of problems. Brachman, et. al., provide a good introduction to the concept of an expert system and describe some applications of this approach. As Johnson (pp. 78-79) notes, an expert, the unit of study in such a modeling effort,

... is a person who, because of training and experience, is able to do things the rest of us cannot; experts are not only proficient but also smooth and efficient in the actions they take. Experts know a great many tricks and have caveats for applying what they know to problems and tasks; they are good at plowing through irrelevant information in order to get at basic issues, and they are good at recognizing the problems they face as instances of types with which they are familiar.

Expert systems can be viewed as means for automating expertise, thereby increasing our supply of a scarce resource. The more immediate and realistic contribution of expert systems research, however, is in expanding our understanding of how experts recognize and solve problems. This is important for DSS design because it is a source of insights about why even experts sometimes make poor decisions and about how problem solving behavior can be improved through support based on models drawn from rational decision theory.

The concept of a DSS is an appropriate one in the context of a farm MIS. DSS are particularly well suited for direct use by farmers in activities that require repeated monitoring, synthesis, and analysis of data, such as commodity marketing management. In a crop marketing DSS I am currently developing, for example, representations include graphic and tabular displays of price forecast

confidence intervals, annual net cash flow cumulative distribution functions and monthly net cash flow confidence intervals associated with alternative marketing strategies, and grain position reports. Operations include stochastic budgeting models for evaluating long term marketing strategies and for ad hoc analyses of shorter term decisions. Data resources include production cost estimates, information about crop yield variability, records of past marketing transactions, and current position data stored at the farm level. Historical price data, regularly updated probabilistic price and basis forecasts, and marketing newsletters are data resources accessed from external sources. Finally, control aids include both menu and command driven control systems that give the user considerable flexibility in the choice of representations and operations.

DSS are also well suited for the support of production management and control activities, such as irrigation scheduling, pest management, and herd health maintenance. They also have the potential to support financial analysis and planning efforts. In these instances, either because their use requires specialized knowledge or because they support activities engaged in only infrequently on any individual farm, DSS are likely to be used primarily by consultants. In these instances, the existence of manageable, well organized data resources will be an almost essential precondition for success. The data resource management issues discussed in the preceding section and the potential for DSS to contribute significantly to more effective farm management are, then, closely linked.

The discussion of DSS to this point has focused primarily on underlying concepts and on the potential for long run benefits from such systems. In the short run, many of the same market related problems that stand in the way of developing more effective record systems are also making it difficult to incorporate DSS concepts into the design of farm MIS. Limited immediate market potential and the lack of adequate data resources at the farm level are particularly important constraints. Ironically, the lack of data resources makes DSS infeasible, yet data resources are not worth developing in the absence of tools such as DSS.

Extension efforts can contribute in at least three important ways to breaking this deadlock. First, as described in the section on data resource management, the application of database concepts in the redesign of farm management association record systems will give both public and private sector DSS developers prototypical data resources to design their systems around. Second, public sector development of prototypical DSS will be important as a source of ideas and as a focus for discussion of design issues. Though this might be viewed as a research effort, the necessity of involving users extensively in the DSS design process suggests that development of DSS prototypes can best be accomplished through joint efforts of researchers and extension specialists. Finally, because of the emphasis in DSS design on support for rather than automation of managerial activities, DSS will be most effective in the hands of well trained managers. Extension programs need to continue emphasizing training in basic managerial skills and in the appropriate use of models designed to support management activities.

The Role of Extension in Farm Information System Development

The same technological changes that are making new things possible in the design and development of farm MIS are making it more difficult to determine Extension's role in this area. We now see increased private sector activity in areas where public sector institutions have previously played a dominant role. In this concluding section, Extension's role in designing, developing, and implementing farm information systems is examined from a relatively broad perspective. Attention is given to educational program design, applied research efforts, electronic data provision, and relationships with the private sector.

This discussion is based on the premise that the mission of Extension is to promote and facilitate technological innovation and to ensure equitable access to data and information generated by the public sector. This mission is justified from a societal point of view because of the important productivity increases that can result from work directed toward it. From the perspective of the discussion here, this mission statement should provide some guidance for deciding what are and are not appropriate roles for Extension in farm MIS development.

In the area of educational programming, Extension clearly will have an important continuing role in providing training on basic management skills such as budgeting and financial statement analysis. For many, poor management and quantitative skills, not a lack of computer literacy, are the major barriers to effective use of farm MIS. The best spreadsheet package is of little use to the manager who does not know where to begin developing financial projections for his business, and the most effectively designed database has no value if users do not know what they want to retrieve from it.

What might be called systems analysis workshops could be another useful kind of educational program. These would be sessions designed to help producers evaluate their own information needs and alternative strategies for meeting them. Such workshops could be organized around relatively well developed structured systems analysis and design procedures, such as those described by Davis. The end product would be well defined information requirements and an MIS development plan for each participant.

In the area of applied research, the need for public sector efforts in prototyping new MIS components has been discussed at several points in the preceding sections. Such efforts give both end users and private sector MIS developers an initial exposure to new ideas and should be useful in providing a basis for the dialogue needed to establish database and applications system standards. Prototyping can also be helpful in refining our understanding of users' needs, since it is always easier for people to say what is good or bad about an existing system than it is for them to say what should be in a good system. There are dangers in prototyping, however. First, it may discourage private sector inventive activity, since it is likely to be less expensive for software designers to borrow ideas than to develop their own. In addition, prototypes can become commercial products, and there is considerable controversy over how to transfer property rights for products developed through public efforts to the private sector. The hybrid seed industry, in which inbred lines are developed primarily through public sector efforts and crosses are developed by private firms, may be a good model for defining appropriate roles in MIS development and limits on prototyping. Public efforts may focus on general design issues and on

the development of generic software modules, while private sector efforts are likely to emphasize final product development. As in the seed industry, however, new technology can bring new problems, and these issues are much easier to think about in principle than they are to deal with in practice.

Commercial software evaluation is another possible area for applied research efforts. This has been the subject of some controversy. From a technology transfer standpoint, reductions in farmers' uncertainty about the quality of software packages should encourage adoption of new MIS products and services. Reliable evaluations would also help farmers choose appropriate software for their operations, since they would provide a consistent set of comparable data on the products tested. Finally, as data management and programming standards designed to permit more integration in farm MIS are developed, software reviews could help encourage adherence to them. On the negative side, software evaluations are costly to do properly, and generally accepted performance criteria do not exist for most application software categories. Furthermore, the establishment of stable software categories may, itself, prove difficult in such a rapidly evolving market. Finally, because software developers can often modify programs to correct problems identified by reviewers, it may be necessary to repeatedly evaluate some new products. Overall, it seems likely that the benefits of evaluation efforts outweigh the costs, but this is an activity that should be initiated with caution. Because evaluation efforts are costly and produce outputs that are easily transferred, regional coordination should be encouraged.

Turning next to the issue of Extension's role as a provider of data and information in electronic form, it seems unlikely that many states will expand their efforts for maintaining networks designed to deliver data directly to farm users. Given the changes in the telecommunications industry brought on by both technical advances and deregulation, this will not be economically or politically feasible. Extension is likely to have an important role in the data delivery industry, however, as a provider of data and information to systems run by private sector firms. In this role, emphasis should be placed on providing data and information that is not time sensitive and is unlikely to be provided by other sources--e.g. planning prices, enterprise cost data, and financial ratio standards based on farm management association data. In this role, Extension can also act as an innovator, experimenting with new types of information and new data formats--e.g. probabilistic price forecasts formatted to facilitate downloading into stochastic budgeting models.

In each of these three areas--educational programming, applied research, and the provision of data and information--Extension's most important contribution will be to serve as a catalyst. Extension efforts can help users understand both the potential for and the limitations of farm MIS. They can also be instrumental in helping MIS developers overcome both technical problems and some of the uncertainties of a rapidly evolving market. One of the most difficult challenges for people working in Extension will be to continue innovating and to maintain an emphasis on encouraging the development and adoption of new information technology based tools designed to support managerial work.

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