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Decision support systems in Australian agriculture: state of the art and future development

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Abstract. This paper reports and discusses the results of a survey conducted among experts working in the field of decision support systems (DSS) in Australian agriculture. It also reviews the literature on DSS in the light of these experts' responses. The findings from this survey have consolidated our understanding of the current state of DSS in Australian agriculture. The uptake of DSS by farmers has been slow and various issues said to be contributing to this include fear of using computers, time constraints, poor marketing, complexity, lack of local relevance, lack of end-user involvement, and mismatched objectives between developers and users. The future prospects for the development of DSS were generally regarded as poor. Nevertheless, the authors believe that new DSS which embrace suggested criteria for developing them could be widely accepted by farmers. These criteria mean that to be widely used by farmers, any successful DSS needs to address widespread problems: they need to be location specific, and gain strong support from initial users. They also need to be simple to use, relevant, effective, low cost, and user-friendly, and it is most likely that farmers would have been involved in their development. We believe that farmers' personalities, and their attitudes towards risk management and decision making, will influence the pattern of adoption of DSS in Australian agriculture while the intergenerational change that is occurring in the management of Australian farms is a positive factor that may encourage more widespread use of these tools.

Keywords: DSS, farmers' decision-making, management decisions.

Introduction

In 2005, when the principal author was partway through his PhD study and considering whether to develop a decision support system (DSS) for managers of mixed farming enterprises in southwest Queensland, a survey was conducted among Australian agricultural scientists then working with, or knowledgeable about, these systems. Focus group discussions with dryland farmers at Roma in southwest Queensland conducted as part of that study had revealed that a decision support tool could help them assess crop planting options in their very risky farming environment. This led to the conduct of a survey among experts in the field prior to making a decision about whether to proceed with the development of a decision support tool for these farmers and their particular problem.

A brief history of the development and application of decision support systems (DSS) in agriculture can be found in the work of Power (2003). Among early authors writing on this topic, Finlay (1994) defined a DSS broadly as a computer-based system supporting the decision-making process, while Cox (1996) noted that the acronym 'DSS' was used increasingly in a loose sense

to indicate any kind of decision aid, whether computer-based or not, and irrespective of whether the problem it purported to address was more or less well structured. According to Meinke et al. (2001), a DSS can describe any normative information-based systems, including software products and dissemination of such information via printed or web-based media. Lynch (2003) called these systems 'intelligent support systems'.

Hayman (2004) noted that the use of DSS in Australian broadacre farming has been reviewed from several perspectives. Macadam et al. (1990) took a soft systems approach, Cox (1996) reviewed the design of these aids, and Lynch et al. (2000) examined the degree of end-users' involvement. Robinson's PhD study (Robinson 2004) is one of the most detailed studies of DSS in Australia (D Freebairn, pers. comm., 18 May 2005). In his study, Robinson reviewed various guidelines for designing a DSS. These guidelines were suggested by various Australian authors including Dillon (1979), Malcolm (1990), Hamilton (1995), Cox (1996), McCown (2002a), and Lynch (2003). As a consequence, the number of attributes that are regarded as essential for the development of a successful DSS has

increased as the evolutionary process has unfolded over time.

Expert survey

Objectives of the survey

The main objectives of this survey were to ask for advice and suggestions from leading practitioners in the field of developing DSS in Australia about designing a DSS for farmers and to understand the current adoption patterns for DSS in Australian agriculture. It was felt that it would be useful to preview the likely future development of DSS and to assess the possibility and appropriateness of designing something (a decision support tool) to help dryland farmers make better crop choices and more appropriate planting decisions.

Expert selection

Experts were chosen on the basis of their publication record in the field of DSS and their working experiences in this field in Australia. A questionnaire was emailed to each of them. In total, questionnaires were emailed to 23 experts, who worked for various universities and research and extension organisations in Australia. Three main questions were asked to pursue the objectives described previously. The response rate (19 out of 23 requests) was impressive, given factors such as the time pressure on respondents, that the questions were open-ended, and that most of the experts selected knew little about the enquirer or his PhD study. The following section will report on these responses to the survey and address some insights and reflections.

Summary and discussion of survey feedback

The first question asked for experts' suggestions about designing a DSS for farmers.

1. What guidelines would you suggest when designing a DSS for farmers?

The following points summarise the concepts that experts suggested should control the design of DSS for farmers:

- It should be relevant to a problem that is causing considerable concern to farmers;
- It is desirable to work closely with farmers throughout the design phase;
- Developers need to take the farmers' point of view and make the DSS very simple and quick to use;
- Each DSS needs easily accessed information sources;

- Developers must know the range of options among which the farmers may need to choose; and
- DSS are useful as the focus for a process of communication among farmers.

Some of these ideas were previously described in Robinson's work (2004), but respondents generally confirmed that any DSS needs to address issues that are causing considerable concern to a particular group of farmers. In other words, the DSS can help to alleviate something that is worrying the farmers or causing them some anxiety. "Make sure that the DSS is on a topic that farmers need the DSS for". It should be an issue that farmers are not already making good decisions about, and something that farmers themselves think they are struggling with or need help with.

It is clear that there needs to be close collaboration with farmers throughout the design phase if the DSS is going to be useful. This is to make sure that the DSS really meets farmers' needs, is understandable, and easy to use.

"To be useful to decision makers, requires [the DSS developer] getting into their shoes". For any decision support tool to be useful, it needs to provide information that is relevant to at least one important decision made by farmers. This means that developers need to be explicit about which decision they are trying to address, when this decision needs to be made, and produce the DSS in a form that is accessible when the decision point arrives. It was suggested that the task needs to be approached from the farmers' point of view, and should not necessarily be considered in the way that researchers would approach the problem.

Respondents shared a common view that unless the DSS is very simple and quick to use, the majority of farmers are unlikely to use it. "The simplest things generally work best, and the simpler the better". However, the drive for simplicity should not mean that important relationships are neglected from the complexity of real decision-making. It was also claimed that some DSS that are useful are essentially easily accessed information sources (e.g. agricultural chemical reference charts and agronomic packages for crop management). Users' preferences for simple DSS have been widely documented in the literature, e.g. Knight and Mumford (1994), Freebairn (2002), Armstrong et al. (2003), and Cox et al. (2004).

It was argued that a DSS should support a decision and not merely provide information,

so in developing a DSS, it would be useful to consider carefully the decision making process that farmers use to make a particular decision. To do this, the DSS developer(s) need to consider various issues, including the decision that needs to be made, the range of options that the farmers may have to choose from (assuming that a 'decision' is a choice between a number of potential courses of action), and the economic, environmental, and social factors that might influence the decision or the choice of an option. In this regard, it is vitally important that the objective that the decision-maker has when making his/her decision is actually reflected by the DSS.

To be effective, "Any decision support tool must find a place within a process of communication". It was suggested that, before launching into a DSS effort, developer(s) need to think long and hard about what is being communicated, to whom, and why. "It is very important to choose a communication medium and design the tool interface with the communication process in mind".

While most recent developments have been computerised, there were some respondents who favoured paper-based DSS. "The most likely DSS to work is in a text form, posing questions or scenarios and providing some answers or alternatives". Computer driven DSS were generally criticised because they have not been used much by farmers.

2. a) What do you think about the adoption rate for DSS in Australian agriculture?

The second group of questions that respondents were asked were about the adoption pattern of DSS in Australian agriculture.

The views expressed by experts are summarised in the following points:

- The use of DSS is extremely low and they are poorly adopted by farmers;
- The main audience is farm advisors; and
- Younger farmers are becoming more accepting of DSS.

The consensus among respondents was that the adoption of DSS by Australian farmers has been very slow. It was also indicated that DSS were not used directly by most farmers. "The main audience is farm advisors and researchers". Pessimistically, some respondents to the survey claimed that DSS tools for farmers were mostly a waste of time and money. "Adoption is abysmal with many millions of dollars wasted on DSS" and "The area of your questions has been well worked

by APSRU [Agricultural Production System Research Unit] in recent years. Our experience is that DSS targeted at farmers are not usually that successful". Nevertheless, others respondents were confident that younger farmers and new agricultural graduates are becoming more accepting of the use of DSS.

Experts' responses to this question were similar to what has been reported in the literature. For example, Edwards-Jones (1992), Lynch et al. (2000), and McCown (2001) all presented evidence of lack of success in implementing DSS in agricultural decision-making. Many other scholars have also reported on the low rate of adoption of DSS by farmers in Australia (McCown 2002a; Nelson et al. 2002; Wensveen 2004; Carberry 2004).

2. b) What are the main contributions of DSS in agriculture today?

Respondents' answers can be summarised in two points:

- Agricultural DSS are able to extend the knowledge of farm advisors; and
- They are best used as a learning tool in a workshop setting.

The contribution to better farm management attributable to the development of various DSS in Australia has been to enhance the knowledge of farm advisors/consultants and boost the value of information they provide to farmers. They were also seen to be useful in a workshop setting where discussion could be focused on decision-making in general or concentrated on making a particular decision that was relevant to a group of farmers. Another contribution would be in research and training. "They might be more useful to the people who build them to structure their knowledge, than to the farmers". The application of DSS for educational use has been reported recently in the literature (Daily et al. 2000; Moore 2005).

2. c) What sort of issues limit the usefulness of DSS or their uptake by farmers?

The answers to this question are summarised in the following points:

- Farmers can make good decisions without using a DSS;
- Many farmers are not computer oriented;
- Most DSS are not well designed and are complex;
- Farmers deal with issues in different ways to researchers;

- Farmers are often short of time [to learn and to use a DSS]; and
- DSS have not been well marketed.

Among the many reasons suggested to explain the slow uptake of DSS by farmers, there was a realisation that “Farmers can make good decisions without them”. This was a common response. In addition, many farmers are not comfortable using computers (although this is changing rapidly). Nevertheless, the farmers are not as computer-literate as the DSS developer(s) and this leads to problems with the use of these products. Hayman (2004) warned that the high ownership but low use of computers for farm management decision-making was one of the major reasons to rethink the approach to promoting DSS as a direct way of improving farm management.

The fact that most DSS are not well designed or are not focused on appropriate topics was also criticized. In addition, they do not really reflect how farmers make decisions. Moreover, farmers deal with different components of the issues and deal with them in different ways to researchers, while “DSS are often oriented to researchers’ perspectives”. In many cases, DSS are too general and not specific to each farmer’s own circumstances. They sometimes require input data which farmers do not have. The ‘mismatch’ between DSS developer(s) and end-users has been widely documented in the literature (Hochman et al. 1994; Robinson and Freebairn 2000; Pannell et al. 2000; Keating and McCown 2001).

Another reason noted for the failure of farmers to use a DSS was that farmers are always busy. “They do not simply have time to learn and use the DSS”. Therefore, they usually get their farm advisors to help them with strategic or tactical planning and the software that goes with it. “Farmers do not have time for tinkering with software which they may only need to use twice a year for planning purposes” so they get specialists in for that because consultants or researchers work with many clients using the same software. These service providers earn their living from applying these DSS so they have an incentive to keep up to date with any development in them. From an economic point of view, the marginal cost of using DSS software and the training required to make sensible use of them is likely to be high for a ‘irregular’ user (a farmer) and low for a regular, power user.

Furthermore, DSS generally have not been well marketed. Most farmers do not know that they exist or what they can do. In practice, DSS are developed by researchers

as part of their project work and this development is usually funded by institutions that do not have a profit motive and often little customer focus. The project usually achieves its objective of developing the first and possibly even the second version of the software before the funds run out, and the project ends. Researchers (modellers and developers) then move on to other jobs leaving the DSS abandoned. “The DSS sits on the shelf and becomes obsolete in a very short time”. No one has the incentive or the inclination to keep it up to date, and keeping it consistent with changes in computing hardware and software technology is quite demanding, let alone the effort required to address the changes in users’ needs.

In the literature, many scholars, including Cox (1996), Hayman and Easdown (2002), and McCown (2002a), have also listed various other attributes that dissuade DSS users. These included fear of using computers, tedious data entry, complicated set up processes, as well as lack of software support, technical interpretation, and application or local relevance.

2. d) How much are farmers part of the process of initiating the requirement for, design, and testing of DSS?

The responses can be summarised in two points:

- Farmers are not involved in many cases – they are often left out of the process; and
- Young farmers with tertiary training are often involved.

Ideally, farmers need a substantial and active role in the whole process from assessing the need for, design of, and testing of DSS. In reality, however, the users have not been involved as much as they could be in many cases. It was generally concluded that the farmers are left out of these processes. “Scientists seem to replicate their own decision-making processes and believe that it is the same way as farmers make decisions”. In practice, the farmers who are often involved in testing DSS are part of a small percentage of computer-literate users – often young farmers with tertiary education. “But even then they will mostly play with a DSS tool and possibly learn something useful from it, and not use it again”.

3. a) What is your opinion about the future development of DSS in Australian agriculture?

The third group of questions asked the experts their opinion about the future development of DSS.

The responses from experts can be summarised as follows:

- The future for developing DSS is not good;
- The commercial market for DSS is likely to remain small;
- They will continue to be developed regularly for many different sorts of decisions, and
- Useful DSS would have been, and will be, adopted.

It was generally believed that the future for developing DSS for Australian farmers was not good. "GRDC [Grains Research and Development Corporation] used not to fund research without a DSS being developed from it, now they have probably gone the other way and know that DSS systems sit in cupboards". Concern was also expressed that the commercial market for DSS was likely to remain small, so there are likely to be few commercial opportunities for private investment in DSS. "Strong competition for scarce public R&D funds will see limited investment in DSS in future". A similar future for DSS has been predicted in the literature (Cox 1996; Freebairn et al. 2002; Hayman 2004).

The profitability of developing DSS was questioned: "Think about it. Why would you spend all the R&D effort to make a tool that will only at best be adopted by ten percent of all the firms in an industry such as agriculture? It's not a great business model". It was also acknowledged that this is a very difficult field to work in. "Please note that I have tried to make, promote, sell, and use DSS for years but my experience is still not all embracing of this issue".

There was a comment that DSS will continue to be developed regularly to address many sorts of issues, but "... farmers will continue to not use them". Nevertheless, some experts optimistically believed that useful DSS would have been, and will be, adopted. This is in line with conclusions from well-known DSS scholars (Hammer et al. 2001; McCown 2002b; Robinson 2004; Matthews et al. 2005). Given the slow acceptance by farmers, respondents raised the importance of targeting farm advisors/consultants. In addition, DSS were said to capture the aspirations of the undergraduate student; and developing and delivering scientific knowledge in a way that supports farmers' decision-making seems a job worth doing.

3. b) What criteria will describe DSS that are widely adopted?

Suggestions of experts are summarised in the following points:

- There are a wide range of farm management problems that need to be addressed;
- These products need to be location specific;
- There needs to be strong support from initial users;
- Relevance, simplicity, effectiveness, and low cost are key attributes;
- Products other than computer-based products should be considered; and
- Users need to be closely involved in the development of these products.

Respondents suggested many criteria that need to be met for broad adoption of a DSS to occur. The DSS needs to focus on a widespread problem or opportunity, which means it meets the needs of a large number of potential users. Also, that opportunity or problem must be sufficiently complex to require a DSS. This might be useful in situations when farmers cannot just telephone a friend or a neighbour to get advice.

The returns (losses) from making a 'correct' ('wrong') decision must be sufficiently large to warrant investing in time and resources to ensure the best (not necessarily right) decision is made. "The 'right' decision needs to be location specific". There was consensus that things developed close to home are generally the most focused and more likely to be used.

"Initial users of the DSS can advocate its use to other farmers". This is very important to increase the adoption rate. Indeed, many farmers still stick to the old saying 'If something ain't broke, don't fix it' when they come to adopting a new tool or new technology. Therefore, if farmers do not know about the usefulness of a DSS and appreciate how using it can help, they will be unlikely to 'give it a go'.

Other essential criteria included ease of use, simplicity, effectiveness, low costs, and user-orientation. Advances in computing technology and the accumulation of experience have changed the DSS landscape in recent years. However, some respondents noted that nothing has changed with respect to organisational commitment, i.e. "Only the simplest decision calculus will succeed with a short-term investment". Also, there is a great deal of competition for farmers' time and that needs to be taken into account.

Following suggestions made in preceding paragraphs, a DSS does not necessarily have to be computer-based. Rules of thumb, decision trees, or paper-based tools may actually work better than computer-based aids in many cases. Easy-to-use models and decision support tools are more likely to be used. "Because seasons, soils, and farmers are so variable, the answers from simple approaches are usually as good as or better than a fancy model".

Close involvement of potential users at all stages in the DSS development process will ensure that the final product will be well accepted. "Test, test, and re-test with real users". It was stressed that the target group needs to be chosen carefully so that it includes mainly people who already have aspirations to do better in the relevant problem domain.

Ultimately, there is no replacement for experts. Without them to interpret the results, models can be dangerous or at best misleading. In most farming systems, "The farmer is clearly the best expert", and expert farmers generally use a range of other experts to support their decision-making.

Conclusions

This survey has revealed many valuable guidelines for designing DSS for farmers. The responses from experts consolidated the authors' understanding about the current state of DSS in Australian agriculture. Experts' responses have reinforced many points reported in the literature. In that regard, the uptake of DSS has been slow and various issues contributing to this include fear of using computers, time constraints, complexity, lack of local relevance, lack of end-user involvement, and mismatching between developers' and users' understanding of requirements. The future prospects for the development of DSS were generally predicted to be poor. However, the authors believe that new DSS, having appropriate attributes and developed according to suggested pathways, could still be widely accepted. We also believe that farmers' personalities and their attitudes towards risk management and decision making will play an important role in deciding the adoption rate of DSS. The recent detailed study by Marchant (2003) provides some interesting insights into this aspect of farmers' decision-making processes. The intergenerational change underway in Australian farm ownership may also influence the pattern of adoption of computer based technologies (Plowman et al. 2004; Foskey 2005). Younger and better educated managers are taking over farm businesses as

the older generation moves out. This might be the basis to suggest that the time is coming when DSS might play a greater role in farmers' decision-making processes.

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