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

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Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

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Abstract

This paper reports and discusses the results of a survey conducted with 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 prospect for the development of DSS was generally regarded to be poor. Never-the-less, the authors believe that new DSS which embrace the suggested criteria 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, expert opinion, management decisions

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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 currently working with, or knowledgeable about, these systems. Focus group discussions held with dryland farmers at Roma in southwest Queensland as part of this 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 idea of conducting the 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 decision support systems (DSS) can be found in 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), DSS refer to all 'normative' approaches of simulation based information provision, 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 research (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 (2002), 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 survey

The main objective of this survey was to obtain advice from leading practitioners in the field before setting out to design a DSS for farmers in southwest Queensland. We also wanted to understand the current adoption patterns of DSS in Australian agriculture and to preview the likely future development of DSS.

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 organizations 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

very open-ended, and that most of the experts selected knew very 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.

Response summary and discussion

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

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

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

- Being relevant to a problem that is causing considerable concern to farmers;
- Working closely with farmers throughout the design phase;
- Trying to take the farmers' point of view;
- Making the DSS very simple and quick to use;
- Having easily accessed information sources; and
- Knowing the range of options that the farmer may need to choose from.

Some of these ideas had previously been described in Robinson's work (2004), but respondents generally confirmed that any DSS needs to address issues that are causing considerable concern to farmers. In other words, the DSS can help to alleviate something that is annoying the farmer or causing 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 [when developing a DSS], requires 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". 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 needs to consider various issues, including the decision that needs to be made, the range of options

that the farmer 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.

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

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

The views expressed by experts are summarized in the following dot-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 are not used directly by most farmers. "The main audiences are 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 systems" 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) presented evidence of lack of success in implementing DSS in agricultural decision-making. Many other scholars, *e.g.* McCown (2002), Nelson *et al.* (2002), Wensveen (2004), and Carberry (2004), have also commented on the low rate of adoption of DSS by farmers in Australia.

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

Respondents' answers can be summarized in two dot-points:

- Enhancing the knowledge of farm advisors; and
- 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 they could focus discussion onto decision-making in general or concentrate on making a particular decision that was relevant to a group of farmers. Another contribution would be to research and training. The uptake of DSS for educational use has been reported in the literature by Daily *et al.* (2000) and Moore (2005).

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

The answers to this question are summarized in the following dot-points:

- Farmers can make good decisions without using 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.

There were many reasons suggested to explain the slow uptake of DSS by farmers. "Farmers can make good decisions without them" 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 developers 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 decisions 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 and so 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". The 'mismatch' between DSS developers and end users has been widely documented in the literature, *e.g.* Hochman *et al.* (1994), Robinson and Freebairn (2000), Pannell *et al.* (2000), and Keating and McCown (2001).

Another reason noted for the failure of farmers to use 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”.

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 are usually paid for by institutions that do not have a profit motive and usually 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 (modelers 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 let alone the changes in users’ needs.

In the literature, many scholars, *e.g.* Cox (1996), Hayman and Easdown (2002), and McCown (2002), 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 summarized in two dot-points:

- Not much in many cases – the farmers 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, to 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 the processes. "Scientists seem to replicate their own decision-making processes and believe that is the same way that 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".

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

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

The responses from experts can be summarized as follows:

- The future for developing DSS is not good;
- The commercial market for DSS is likely to remain small; 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 [Grain 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 scare public R&D funds will see limited investment in DSS in future". A similar future for DSS has been predicted in the literature, *e.g.* Cox (1996), Freebairn *et al.* (2002), and 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 say 10% 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".

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, *e.g.* Hammer *et al.* (2001), McCown (2002), Robinson (2004), and Matthews *et al.* (2005). Given the slow acceptance by farmers, respondents raised the importance of targeting farm advisors/consultants.

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

Suggestions of experts are summarized in the following dot-points:

- Widespread problems 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 phone a friend or neighbor for the answer.

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". The consensus was 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, and low costs. Advances in 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 organizational 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.

Conclusion

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 prospect for the development of DSS was

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 agriculture (Plowman *et al.*, 2004; Foskey, 2005) must also influence the pattern of adoption of computer based technologies. 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.

Acknowledgement

All the experts who responded to the survey are acknowledged for their time and valuable advice. This study has financial assistance from an International Postgraduate Research Scholarship (IPRS) at The University of Queensland and the GRDC-funded Western Farming Systems project.

References

Armstrong, D., Gibb, I. and Johnson, F. (2003). 'Decision support - More about learning than software packages?' *Australian Farming Systems Conference*, Toowoomba, Australia.

Carberry, P. S. (2004). 'Crop scientists as change agents', *Proceedings of the 4th International Crop Science Congress*, Brisbane, Australia.

Cox, H. W., Hammer, G., McLean, G. B. and King, C. (2004). 'National WhopperCropper - risk management discussion support software', *Proceedings of the 4th International Crop Science Congress*, Brisbane, Australia.

Cox, P. G. (1996). 'Some issues in the design of agricultural decision support systems', *Agricultural Systems,* **52**, pp 355-381.

Daily, H. G., Hinch, G. N., Scott, J. M. and Nolan, J. V. (2000). *The use of a decision support program to facilitate the teaching of biological principles in the context of agricultural systems*, [Online] Accessed: 23rd February, 2005, Available at:http://www.tedi.uq.edu.au/conferences/teach_conference00/papers/daily-hinch-etal.html.

Dillon, J. L. (1979). 'An evaluation of the state of affairs in farm management', *Southern Journal of Agricultural Economics,* **1**, pp 7-13.

Edwards-Jones, G. (1992). 'Knowledge-based systems for pest management: An application based review', *Pesticide Science,* **36**, pp 143-153.

Finlay, P. N. (1994). *Introducing decision support systems,* Blackwell, Oxford, UK.

Foskey, R. (2005). *Older Farmers and Retirement*, RIRDC Project No UNE 68A, A Report for the Rural Industries Research and Development Corporation.

Freebairn, D. M., Robinson, J. B. and Glanville, S. F. (2002). *Software Tools for Learning and Decision Support*, [Online] Accessed: 6th April, 2005, Available at: http://www.apsru.gov.au/apsru/Projects/wfs/pdffiles/.

Hamilton, N. A. (1995). *Learning to learn with farmers: A case study of an adult learning extension project conducted in Queensland, Australia 1990-1995*, PhD thesis, Landbouw Universiteit Wageningen.

Hammer, G. L., Hansen, J. W., Phillips, J. G., Mjelde, J. W., Hill, H., Love, A. and Potgieter, A. (2001). 'Advances in application of climate prediction in agriculture', *Agricultural Systems,* **70**, pp 515-553.

Hayman, P. (2004). 'Decision support systems in Australia dryland: A promising past, a disappointing present and uncertain future', *Proceedings of the 4th International Crop Science Congress*, Brisbane, Australia.

Hayman, P. T. and Easdown, W. J. (2002). 'An ecology of a DSS: reflections on managing wheat crops in the northeastern Australian grains region with WHEATMAN', *Agricultural Systems,* **74**, pp 57-77.

Hochman, Z., Pearson, C. J. and Litchfield, R. W. (1994). 'Users' attitudes and roles in the development and evaluation of knowledge based decision support systems for agricultural advisers', *Agricultural Systems,* **44**, pp 217-235.

Keating, B. A. and McCown, R. L. (2001). 'Advances in farming systems analyses and intervention', *Agricultural Systems,* **70**, pp 555-579.

Knight, J. D. and Mumford, J. D. (1994). 'Decision support systems in crop protection', *Outlook on Agriculture,* **23**, pp 281-285.

Lynch, T. (2003). *Intelligent support systems in Australian agriculture*, PhD thesis, Central QLD University.

Lynch, T., Gregor, S. and Midsome, D. (2000). 'Intelligent support systems in agriculture: how can we do better?' *Australian Journal of Experimental Agriculture,* **40**, pp 609-621.

Macadam, R., Britton, I., Russell, D., Potts, W., Baillie, B. and Shaw, A. (1990). 'The use of soft systems methodology to improve the adoption by Australian cotton growers of the Siratac computer-based crop management system', *Agricultural Systems,* **349**, pp 1-14.

Malcolm, L. R. (1990). 'Fifty years of farm management in Australia: survey and review', *Review of Marketing and Agricultural Economics,* **58**, pp 24-52.

Marchant, D. D. (2003). *A Study of the Effects of Dairy Farmers' Personalities on Their Risk Attitudes, Decision Making Processes and Risk Management*, PhD thesis, University of Queensland, St Lucia, QLD.

Matthews, K.B., Schwarz,G., Buchan, K. and Rivington, M. (2005). 'Wither Agricultural DSS?', *Proceedings of the 16th International Congress on Modelling and Simulation*, Melbourne, Australia.

McCown, R. L. (2001). 'Learning to bridge the gap between science-based decision support and the practice of farming: evolution in paradigms of model-based research and intervention from design to dialogue', *Australian Journal of Agricultural Research,* **52**, pp 549-571.

McCown, R. L. (2002). 'Changing systems for supporting farmers' decisions: problems, paradigms, and prospects', *Agricultural Systems,* **74**, pp 179-220.

Meinke, H., Baethgen, W. E., Carberry, P. S., Donatellic, M., Hammer, G. L., Selvaraju, R. and Sto¨ ckle, C. O. (2001). 'Increasing profits and reducing risks in crop production using participatory systems simulation approaches', *Agricultural Systems,* **70**, pp 493-513.

Moore, A. D. (2005). 'Paying for our keep: grasslands decision support in more-developed countries', In *Grassland: a global resource*, (McGilloway, D. A., *eds*), Wageningen Academic Publishers, The Netherlands, pp. 403-414.

Nelson, R. A., Holzworth, D. P., Hammer, G. L. and Hayman, P. T. (2002). 'Infusing the use of seasonal climate forecasting into crop management practice in North East Australia using discussion support software', *Agricultural Systems,* **74**, pp 393-414.

Pannell, D. J., Malcolm, L. R. and Kingwell, R. S. (2000). 'Are we risking too much? Perspectives on risk in farm modeling', *Agricultural Economics,* **23**, pp 69-78.

Plowman, I., Garder, J., Ashkanasy, N. M. and Letts, M. (2004). *Innovation in rural Queensland: why some primary industries and their associations thrive while others languish*, Linkage Project LP0218238, An Australian Research Council-funded partnership between The University of Queensland and the Department of Primary Industries and Fisheries, Queensland.

Power, D. J. (2003). *A Brief History of Decision Support Systems*, [Online] Accessed: 20 June, 2005, Available at: http://dssresources.com/history/dsshistory.html.

Robinson, J. B. (2004). *Understanding and applying decision support systems in Australian farming systems research*, PhD thesis, University of Western Sydney, NSW, Australia.

Robinson, J. B. and Freebairn, D. M. (2000). 'The Decision-Maker has an Important, but Often Neglected, Role in Model Use', *Modsim 2000*, Canberra, Australia.

Wensveen, M. V. (2004). *Increasing the value of decision support tools for farmers*, [Online] Accessed: 6th April, 2005, Available at: http://www.csiro.au/proprietaryDocuments/SEI_FARMSCAPE.pdf.