A sociological approach to the participatory development of agricultural decision support systems

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Abstract

Farming systems are characterised by complex interactions between a range of economic, environmental and social factors. This complexity has led to a search for ways in which scientific knowledge can be incorporated into forms that industry stakeholders can use to assist their management decisions. Decision support systems (DSSs) are one of the ways in which scientists have attempted to make agricultural systems science more accessible and useful for industry stakeholders. Recently, there has been a shift towards more participatory processes in development and application of DSSs. We have analysed these processes using concepts from the sociology of science and technology, and developed a framework for describing the phases of this participatory process and its likely outcomes. Understanding these phases may provide greater certainty that the process will result in the desired productive relationships and mutual understanding. We identify three outcomes of participatory DSS development. Firstly, interactions around DSSs may lead to practice change, resulting from greater capacity built amongst participants during the interactions; however the DSS itself may not be subsequently used. Secondly, DSSs may be used by industry stakeholders on an ongoing basis to improve practice. Thirdly, the interactions may support current management practices and the DSS provides little additional benefit. We propose that participatory DSS development and/or application should be viewed as a learning process leading to knowledge acquisition, rather than a software development process. We illustrate these concepts with a case study from the sugar industry.

Key Words

DSS, models, participatory action research, science and technology studies, sociology, extension, diffusion

Introduction

The development of decision support systems (DSSs) has been one way in which scientists have attempted to help farmers deal with the complexity of optimising farming systems. DSSs can be described as *knowledge intensive* innovations, because they require people to learn new knowledge and skills to operate the technology effectively and interpret its outputs (Audirac and Beaulieu 1986). There has been a move to participatory action research (PAR) in the development of DSSs, in an attempt to increase their generally low adoption rate (McCown *et al*. 2002). This move is consistent with the wider use of PAR principles in developing knowledge intensive technologies to ensure their relevance and effectiveness (Douthwaite *et al*. 2001). The shift towards participatory development of agricultural DSSs opens opportunities for new ways of thinking about DSS development. The sociology of both science and technology describes how science and technology are produced through social relationships and practices, and so might inform and understand participatory DSS development and/or application.

In the paper we describe and then use concepts from the sociology of science and technology to develop a framework that provides a new perspective on participatory process, which is richer than the traditional diffusion of innovations perspective. We illustrate the application of the framework through a case study of the use of agricultural DSSs for improved management of sugarcane production systems.

Sociological framework

Science and technology studies demonstrate that ‘scientific knowledge is not the passive product of nature but an actively negotiated, social product of human inquiry’ (Cozzens and Woodhouse 1995:534) and that technology is ‘a social product, patterned by the conditions of its creation and use’ (Williams and Edge 1996:866). There are three concepts in science and technology studies that help understand the process of DSS development and/or application, they are *Interpretative flexibility, Technological frames* and *Boundary objects* (illustrated in Figure 1):

Interpretative flexibility means that any object can mean different things to different people, depending on the contextual factors (Hess 1997). When applied to DSSs, the concept of interpretative flexibility emphasises that a DSS will mean different things to the various people, e.g. farmers, extension officers, scientists, involved in its development and/or application, and these different views are equally valid.

Technological frames are the assumptions, beliefs and expectations that groups of people hold about a specific technology, which in turn influence the design and use of that technology. People can hold different frames about the real world, its representation through science, etc. When the frames of different people become similar they are termed as being *congruent* (Orlikowski and Gash 1994). *Incongruent* technological frames can lead to conflicts over the use and value of a technology and hence create difficulties for its application. It is hoped participatory processes result in increasingly congruent technological frames.

Boundary objects ‘are objects which are plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity’ (Star and Griesemer 1989: 393). Cash (2001) described how scientific models can act as boundary objects in agricultural extension: ‘models themselves can act as boundary objects, dependent on both the participation of farmers to get inputs that reflect reality and outputs that are useful, as well as on scientists who incorporate basic research on the systems under study and the technical capacity to guide the endeavour’ (Cash 2001:441).

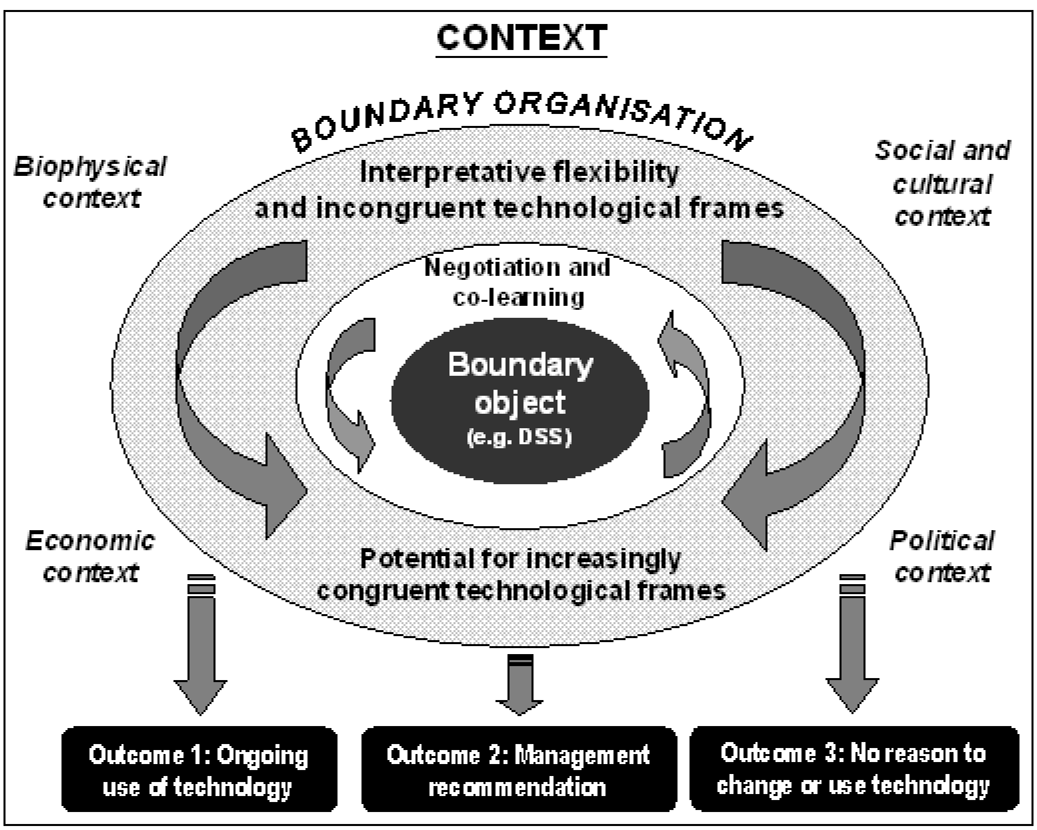

Figure 1. Theoretical framework of the context, processes and outcomes of participatory DSS development

Participatory DSS development/application is an interplay between these three concepts. A DSS will act as a boundary object, creating a temporary bridge that promotes dialogue between the various people involved in its development and/or application, while remaining flexible enough to be utilised by the different parties for their own purposes. Interpretive flexibility allows the DSS to serve as a boundary object, and highlights the different goals people have when working with DSSs. Through the negotiation, cooperation and co-learning that the DSS-as-boundary object can facilitate, the parties involved may arrive at an increasingly shared understanding of the problem. This works towards increasingly congruent technological frames. Obviously any technology, including a DSS, is conditioned by, and embedded in (Figure 1) its external social, cultural, political, economic and biophysical context which must be considered during these interactions.

The framework also highlights three potential outcomes of participatory DSS development (Figure 1). Outcome 1 may be acceptance by potential users of the value of ongoing use of the DSS, which may necessitate further cycles of negotiation and co-learning to, for example, make the software more user-friendly. This corresponds to more classical participatory DSS development. Once the DSS is ready for routine use, emphasis shifts from negotiation and co-learning to adoption of the DSS by farmers and/or advisors through standard diffusion and extension programs.

However, the cycles of negotiation and co-learning that occur through participatory DSS development or application may lead to a better understanding of the problem and its context. This may allow for simplification of the problem within the specific management and/or biophysical context and result in the discovery of a new and widely applicable management practice. This practice can be extended as a management recommendation for farmers without ongoing use of the DSS (Outcome 2). In this situation the DSS may be seen as having been more applied than developed.

The framework also recognises that, through the DSS development process, the parties involved may find that there is no reason to change current practice (Outcome 3). This outcome may occur because the process has led to a better understanding of the problem and acceptance, especially by the farmers involved, that there is no opportunity for, or little benefit from changing current management practice. If some parties, e.g. the scientists, disagree with this view, the technological frames are obviously incongruent.

Case studies

The use of the framework to describe interactions in the development/application of agricultural DSSs has been examined through a case study at Tully (North Qld). The case study group wanted to increase sustainability of nitrogen (N) fertiliser management within sugarcane farming in their region. They thought that seasonal climate forecasting could possibly help reduce environmental N losses, whilst increasing crop yields. These issues were examined in a participatory approach by simulating sugarcane production systems in Tully under a range of management options with the APSIM-Sugarcane cropping system model (Thorburn *et al.* 2005). During the study the following issues were examined iteratively: (1) Identifying the management practices that might provide improved sustainability, then (2) analysing the potential outcomes of these management practices, and (3) identifying future actions for the project team and/or region.

“Rules” were constructed by the group describing possible management reactions to different seasonal forecasts. For example, if rainfall was forecast to be above median, half the N fertiliser could be applied at the usual time. The other half could be applied later if the actual rainfall was not as high as forecast. This scenario was tested against a range of others, e.g. either single or split applications of N in all years, reduced rate of N following a wet forecast, etc. Splitting N in all years, regardless of the forecast, was predicted to give higher yields and profits with lower environmental losses compared with the other management options examined, although the differences between several of the scenarios were small.

Semi-structured, in-depth interviews were conducted with case study participants, i.e. the farmers, extension officers and scientists, and their comments illustrate the elements of the framework. For example, the range of expectations the participants initially held about possible direction of the study illustrates the interpretative flexibility that shaped their initial reactions to the study:

…I was curious to see how you could use the nitrogen application part of, with it, which I understand we probably all have our own ideas through experience, about putting on nitrogen in different wet years and dry years, and things like that. (Farmer)

…I suppose [his expectation for the project] was to learn about climate forecasting and how it might be used and the various tools that are available and for nitrogen management. (Extension)

In these participatory simulation exercises APSIM acted as a boundary object. The participants explored the assumptions about nitrogen management and gained a better understanding of the nitrogen cycle and the consequences of different nitrogen management scenarios in that environment:

I was just fascinated with the different responses of the soil types. Sort of say, okay what about this scenario? [The team] could put it into [the model] and got one result and change a few parameters and you come out with totally opposite results. … I do remember if I did two or three splits during those wet years I would have been from 65 to 80 tonnes … better off. …I'm very enthusiastic about it, opened up a lot of possibilities, scenarios, something like that. (Farmer)

However, despite the simulation results showing some advantages from splitting N in all years the local stakeholders' general feeling was that the inconvenience involved in splitting was not worth the benefits identified in the simulations. Although there was some interest in considering splitting in years forecast to have above median rainfall – the less frequent inconvenience might be acceptable for the possible benefits.

There remained a degree of incongruence amongst the technological frames of the case study members:

I don't think I've learnt much more, but I've been [managing nitrogen], you know, pretty right till now. I don't think there's much further I can improve it. (Farmer)

I suppose at the end, I think we all had a very common understanding of the biophysical system but, there [were] some different expectations of what the appropriate management was… In the end, we came up with ways to tweak the system, which fulfilled [the farmers] initial objectives and some of these management actions … [the farmers] … considered quite good. But they weren't looking for tweaking, they were looking for big … silver bullet type change. (Scientist)

…We're looking at a lower rate in... wetter conditions. That's one of the things we're planning. (Extension)

The outcome of this case study was closest to Outcome 3 (Figure 1): the farmers involved found there was no reason to significantly change current practice, although understanding of their system had increased.

Discussion

The sociological framework describes the social context and processes that shape participatory DSS development and/or application. The concepts of interpretative flexibility and technological frames reinforce the importance of acknowledging the different perspectives held by people involved in the participatory process, and then the need/opportunity to work towards a shared understanding. The framework also illustrates the way in which participatory DSS development can break down the barriers between the developers and potential DSS users. When used as a boundary object, a DSS encourages co-learning between those involved in its development. Appreciating the way in which a DSS can act as a boundary object recognises how cooperation and co-learning among those involved in that process can occur, despite the fact that these people can hold diverse perceptions of a DSS or the issue it is designed to address.

Our framework also recognises that a DSS may become redundant once it has fulfilled its function as a tool for co-learning. However, this is a successful outcome when it leads to a clearer understanding of the problem by all and, possibly, a changed management recommendation is developed based on this understanding. While this was the outcome of the case study described in this paper, other the possible outcomes have resulted from other case studies on issues of irrigation scheduling and seasonal climate forecasting (Jakku *et al.* 2007).We hope that our framework provides those involved in the development and/or application of agricultural technologies with new conceptual tools to reflect on their practice and in doing so, contribute to enabling more effective participatory technology development processes.

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