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# Wither agricultural DSS?

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ABSTRACT

Computer-based agricultural decision support systems (aDSS) may be argued to have passed sequentially through phases of unbelief, euphoria and disappointment, and to be currently passing into either a phase of maturity with realistic expectations of the technology, or to abandonment. This paper appraises, in the context of the DSS development literature, our past and current efforts in decision support using simulation-models and farm-scale case-studies. The paper first reviews some of the explanations for the lack of success for aDSS including the identification of suitable roles and how best the tools may be deployed. The paper then outlines the authors' experiences during the euphoric period of aDSS development including the undertaking of market research on the nature of the aDSS desired and their potential for commercialisation. The positive outcome of the market research was that potential end-users recognised the range of functionality that an aDSS could offer. There was, however, significant scepticism on the balance of costs and benefits. The end-user preference for aDSS delivered as software products for use in-house, when combined with the limits on the price-per-unit that the market would bear, meant that there was little commercial potential. In the light of these findings the team re-evaluated the role and development strategy for their aDSS. The paper outlines this strategy in terms of both the technical developments of the aDSS and the approach to its use with stakeholders. The paper then discusses the legacy from the euphoric period highlighting a number of socio-political and institutional barriers to the use of aDSS which remain to be overcome. The paper concludes by arguing that there is a need to think beyond technocentric solutions to overcome the barriers to wider aDSS use and that there are a number of models of best-practice for aDSS development that can ensure their relevance.



## 1. Introduction

### 1.1. Context

Agricultural systems remain the principal land-using sectors in terms of area for much of the EU and elsewhere in the world. The EU policy agenda has, however, moved support from solely encouraging increased agricultural production, to underpin food security and increase rural prosperity, towards *multi-functional* or *post-productivist* rural land use and sustainable development agendas (Scottish Executive, 2001, 2002, 2006a, b). Prosperity of the farming sector is thus increasingly to be balanced with food safety, environmental protection and sustainable development of the rural community as a whole. There is, however, disagreement on the extent to which EU agricultural systems are in reality post-productivist (Wilson, 2004), and particularly the extent to which the values and aspirations of farmers and other land managers have changed (Burton, 2005). It is possible to identify potential *win–win* improvements to resource management within farming sys-

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tems, for example improved fertiliser management to reduce variable production costs and diffuse pollution (Bragg et al., 2005). In other cases, however, there is the need to make transparent and evidence-bounded land management decisions based on the trade-offs in outcomes between individuals or between individuals and the wider public-good (Verweij et al., 2006; Stilgoe et al., 2006). One approach to informing and/or influencing decision making within agricultural systems that has seen considerable investment of research funding is the development and use of agricultural decision support systems (aDSS).

### 1.2. *What are aDSS?*

For the purposes of this paper, the definition of DSS is restricted to computer-based tools, developed (generally by researchers, but not exclusively so) to provide analysis and advice to decision makers.[1] The "a", is added to DSS as a qualifier to distinguish a subset of DSS where decisions on patterns of land use and management are the central activity that the DSS developers are seeking to support. By restricting aDSS to computer-based tools the definition seeks to avoid the absurdities that can occur by including any information source as an aDSS (e.g. leaflets or other knowledge transfer media). For aDSS the emphasis is on *support*, since people make decisions and software at best only assists. aDSS is not about automated control. The *systems* element of aDSS (in contrast to the term *decision support tools*) recognises that aDSS is not only a stand alone software tool but also data, encapsulated knowledge and facilities to communicate or interpret the aDSS outputs. aDSS often have a counter-factual (what-if) analysis role, having the potential to both generate and assess alternative options. Such analysis is based on the use of simulation modelling or other forecasting methods, to support decision making where empirical evaluation of options via experimentation may be prohibitively expensive, too risky, or unethical.[2] The community of interest for aDSS starts with farmers and an organisational scale of individual enterprises (e.g. barley cropping or suckler cattle) or whole farm-business. In this regard, the decisions typically supported are tactical management (improving the sequencing or scheduling of resources to increase returns, reducing risk or limit damaging externalities such as pollution) or strategic management (deciding on the portfolio of enterprises undertaken) (Matthews et al., 1999a). Where trade-offs are being considered then the aDSS community of interest includes other direct and indirect stakeholders such as government, agencies, NGO's and the wider rural and urban publics (e.g. river basin and landscape scales for the EU Water Framework Directive (Blackstock and Richards, 2006) and UK bio-diversity action plans (Redpath et al., 2004)).

[1] In this context, the term decision makers encompass both practitioners who will implement the decisions and stakeholders, such as policy makers and the public, with legitimate interests in the outcomes of the decisions.

[2] The knowledge-based content of aDSS is often, however, based on empirical or experimental research.

### 1.3. *Objectives and structure*

There is a significant body of opinion holding the view that aDSS developed to date have failed to deliver tangible benefits, particularly since there are few examples of widespread or sustained use of aDSS by land managers. This is known as the *problem of implementation*. The objectives of this paper are, to critically reflect on the explanations for these failures available within the aDSS and related literatures, to assess how well these explain the authors' experiences in developing and deploying an aDSS, and to try and identify additional factors that may need to be considered. The paper first reviews a framework of phases within which the history of aDSS development (and current aDSS-like activities) can be understood, and assesses the implications of the four roles in which DSS have been seen to be effective. The paper then identifies key factors in the success of aDSS, arguing that there has been an excessive focus on technological factors rather that recognising the need to ensure that the tools developed are credible with decision makers and to integrate the software into a particular decision making milieu. Against this background the paper presents a retrospective analysis of the authors' experiences in developing an aDSS over the last 15 years. This is presented in three parts. The first part presents the previous research and model building efforts from which the authors' aDSS project was born and charts the initial phase of aDSS building. The second part presents the outcomes of a market research exercise carried out as part of a planned to commercialisation the aDSS in 1999. Some of the results of the market research are now dated (particularly those relating to the use of the Internet). The market research, however, remains compelling evidence for nature of the challenges faced by aDSS developers and supports theories within the aDSS literature. The third part outlines the research team's response to the market research, in particular the development of strategies for using the aDSS as part of a process of engagement between researchers and stakeholders (a knowledge transfer and exchange role) and facilitating interactions between stakeholders groups such as policy makers and land managers (a deliberation role). The paper then highlights significant legacy, socio-political and institutional factors that will, if not addressed, continue to have profound affects on which tools are developed, how they are developed and how effective they are. The paper argues that there is a continuing role of aDSS, that there needs to be realism in the expectations of the technology and that there are significant lessons from the history of aDSS development for other aDSS-like tools being developed in related fields of research.

## 2. Developing and deploying DSS

### 2.1. *DSS development phases*

Within literature assessing the use of new information technologies in management applications there is an increasingly well-developed understanding of the likely phases of development through which a particular technology will pass. Biethahn and Nissen (1995) presents a framework that is particularly useful in understanding the historical trajectory of

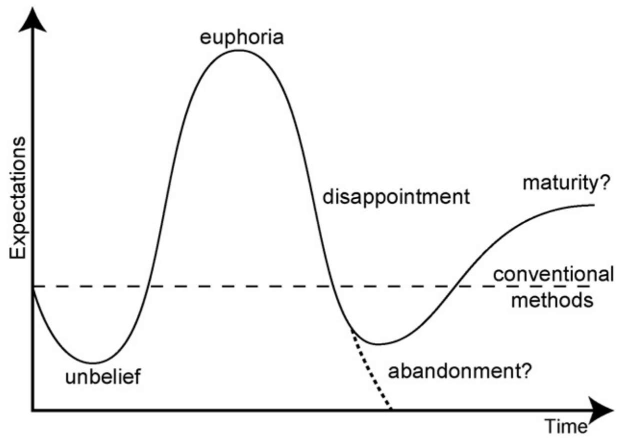


**Fig. 1 – Expectation phases for technologies—modified from (Biethahn and Nissen, 1995).**

aDSS development. They propose that a graph of the expectations for an innovation against time shows a characteristic series of phases (a modified version of their graph is presented in Fig. 1). Four phases are identified that compare performance of the innovation with existing conventional practice, these are: unbelief, euphoria, disappointment and finally maturity. Within this framework we would argue that, in general, aDSS are somewhere between disappointment and maturity. The Biethahn and Nissen framework may, however, be unduly optimistic in that perhaps two alternatives exist after disappointment, namely maturity or abandonment, and it is the latter that has been the fate for sufficient numbers of aDSS to give cause for concern. There are excellent analyses of the causes of disappointment and pathways to maturity that tie the successful use of aDSS back to the way in which they are developed (reviewed below). It is interesting to perhaps consider whether the problems of aDSS have their roots earlier in the period of euphoria, particularly in excessively technocentric development processes and the institutional environment in which aDSS were typically developed.

### 2.2. *DSS roles*

Highly persuasive analyses of the disappointment to maturity phases of aDSS have been presented by Australia-based researchers, who suggest that aDSS suffer from the problem of implementation (McCown, 2002c), that is the lack of sustained use in a way that influenced practice (Carberry et al., 2002). There have been several examples of short-term use of aDSS, mainly in applications with single-issue, influences tactical and productivist goals. These aDSS fill a *calculator* role, making complex, but well structured, calculations or inferences and they encapsulate knowledge that is difficult to derive from experiential learning (McCown, 2002b). These calculator aDSS were, however, often discarded once the knowledge within the aDSS was assimilated. While successful in their primary role there was disappointment that aDSS could not be exploited as an ongoing means of influencing practice. Questions were also raised about the cost effectiveness of, other than the simplest aDSS, as short-term knowledge transfer vehicles. A second class of aDSS identified by (McCown, 2002b), which has seen ongoing use is the *record keeper*. These tools are intended to assist in the adoption of best-management-practice and often address environmental issues (for example the *Your Farm and NVZ's* DSS,[3] designed to assist UK farmers in complying with Nitrate Vulnerable Zone (NVZ) regulations). Despite the potential for win–win outcomes of reduced fertiliser inputs, nutrient management tools in the UK have seen significant adoption only within designated NVZ's where there are financial penalties for non-compliance.

For more complex aDSS intended to address, strategically important and/or poorly structured issues through counterfactual analysis the problem of implementation was more acute. This class of aDSS, defined as *flexible simulators*, had been expected to have the greatest value for decision makers, based on the advice of earlier DSS developers in other milieu, for example Keen and Scott-Morton (1978) and Turban (1995). Disappointment at the lack of end-user adoption lead to a reappraisal both of who would be the users, and what would be the operational role of aDSS (McCown, 2002b). The lack of adoption was seen to have parallels in past attempts to apply DSS based on operational research and other approaches within industrial management (McCown, 2002a). A key conclusion from McCown's review was that it is only through the existence of a partnership between researcher and practitioner, *within* the research project developing the aDSS *and* its operational deployment, that there is much hope of effecting strategic changes. This analysis was further developed by McCown (2002b) in arguing that for DSS to be successful they should try to empower decision makers rather than forcing them to cede agency to *black-box* tools developed by others. The appropriate roles identified for the flexible-simulator based DSS were as a tool for consultants to use in *systems analysis* with land managers and as a *learning environment* for a range of stakeholders concerned with land management issues.

### 2.3. *Key factors in DSS success*

The (McCown, 2002b) analysis also identifies the credibility of the information being provided by the DSS as being the key to its success. Credibility is a complex mix of social and technical aspects that requires developers to concentrate on both social networking and the quality of models/data within the DSS. In cases where either are found to be lacking, it is necessary to invest resources in improving or providing them (Carberry et al., 2002). Credibility is a more convincing explanatory property than solely technocentric explanations such as user-friendliness, simplicity or transparency, since despite substantially increased technological sophistication (comparing tools available in 1990 and 2007), aDSS are, if anything, less influential.[4] Projects that have concentrated on the building of credibility with stakeholders and on aDSS deployment

[3] www.defra-nvz.

[4] This is reflected in recent conference sessions with titles such as "Agricultural DSS useful tools or near extinction?" (Carberry and Ascough, 2005) and "Bridging the gaps between design and use: developing appropriate tools for environmental management and policy" (Matthews et al., 2006b).

strategies, such as FARMSCAPE[5] demonstrate the utility of a participatory action research (PAR) approach, by achieving and maintaining a substantial user-base and in changing practice (Carberry et al., 2002). Despite the evident success of the FARMSCAPE project, relative to other aDSS, it was still criticised as ignoring the research needs of farmers (Ridge and Cox, 2001) and while that view has been disputed (McCown, 2001), there remains concern that those farmers who adopt aDSS tend to be the most innovative.

It is important, however, that PAR not be seen as a universal panacea for the problems of aDSS. As Jakku and Thorburn (2004) note, PAR has both practical and methodological/ethical challenges. Practically, PAR is resource intensive, time consuming, can result in outcomes that are caricatured by conventional researchers as lacking in rigour and result in fewer peer-reviewed journal articles. These are all features that mean funding agencies are less likely to want to undertake PAR-based development of aDSS. Methodological and ethical challenges include the difficulty of identifying stakeholders, the raising of expectations that cannot be fulfilled and unintended negative consequences. Current research teams may also lack personnel trained in the social science theory that underpins the design and/or experience in conducting participatory approaches. Tokenism in participation is a real danger since it both destroys the good will of stakeholders and discredits PAR when projects fail to deliver (Jakku and Thorburn, 2004).

Where progress towards sustainable development or resource management is desired, and this progress depends on the coordinated actions of individual land managers within some larger framework (for example a water catchment or landscape), consideration needs to be given by DSS developers to issues of governance and cooperation issues (Wilson, 2004). PAR-based approaches to DSS use may be less effective, or less feasible, when there are multiple-stakeholders and substantial disagreement on the goals to be achieved and how to evaluate of progress; both agreeing the metrics and their normative interpretation (French and Geldermann, 2005). These disagreements will be compounded when there is significant uncertainty associated with the DSS outcomes or where the scientific basis of the outcomes is contestable. In these circumstances, the role of the DSS may no longer be to provide decision support *per se* but to act as a *boundary object* to help the communication between stakeholder groups with differing perspectives and knowledges. A key feature of boundary objects is that they must be *plastic* enough to be interpretable or manipulatable by each of several parties (Star and Griesemer, 1989) yet *robust* enough to acts as a common point of reference for all (Harvey and Chrisman, 1998). In the case of agricultural aDSS, case-studies of exemplar systems can serve as proxies for real cases, being sufficiently real without being so personal to the stakeholders that deliberation is not possible (Matthews et al., 2006a).

[5] FARMSCAPE is the Farmers', Advisers', Researchers', Monitoring, Simulation, Communication, And Performance Evaluation is a programme of participatory research using the APSIM model conducted by CSIRO (Keating et al., 2003).

Drawing on this analysis of aDSS development and deployment, the remainder of this paper explores, from the perspective of a team involved with a farm-scale land-use planning aDSS (LADSS[6]) in Scotland since 1992, the transitions through the phases of euphoria, and disappointment and proposes a possible route to maturity. The paper also reflects on some of the socio-political circumstances in the UK that continue to shape the development and deployment of agricultural DSS and the challenges for DSS of addressing agri-environmental or sustainable development issues.

## 3. Project background

The lineage of the software tools that continue to be developed by the authors goes back to the 1970s with systems researchers working for the UK Hill Farming Research Organisation using models both as part of the research process and to communicate the outcomes to land managers. The early models had a principal focus on the prediction of off-take and growth of sheep (Armstrong, 1985), later models also included forestry and did so in a spatially explicit manner using grids of cells (Maxwell and Sibbald, 1979). From the late 80's onwards there was a divergence in the models with semi-natural pastures tackled by one team with an emphasis on predicting the impacts of grazing on key herbage species, Hill Grazing Management Models (HGMM) I-III, and later HillPlan (Armstrong et al., 1997). The land use planning for upland farms was undertaken within a second project (which perhaps significantly had no acronym) (Butcher, 1991). From 1992 onwards this latter model served as the basis for a land use planning DSS with development efforts focused on the integration of a geographical information system with the land use systems models (Matthews et al., 1999b). The application focus during this period was on the strategic analysis of farming systems in order to assess the effects of, or responses to, policy with the client seen as the policy divisions of the then Scottish Office. During this period, there was an increasing pressure for Research Institutes in Scotland to secure income in addition to their core government funding which was decreasing. One of the options considered was to take the then prototype LADSS and to develop it commercially. There was significant debate about the nature of the commercialisation – with the debate informed by the Australian experience following a visit to CSIRO in 1995 and a workshop with a range of Scotland based stakeholders in late 1997. This led to a formal market research survey, completed in early 1999. The outcomes of the market research led to a significant reappraisal of the efforts in aDSS development and deployment (discussed further in Section 5).

## 4. Market research

### 4.1. Market research methods

The market research was undertaken by Systems Insight (SI), a market research agency specialising in strategic and mar-

[6] Land Allocation Decision Support System.

**Table 1 – Survey questions**

| No. | Question |
|---|---|
| 1 | Which of the following (list of activities—see Table 3) lie within your areas of responsibility? |
| 2 | What tools and resources (see Table 4) does your organisation mainly use? |
| 3 | How satisfied are you that the tools and resources indicated in Q2 provide an effective and reliable basis for decisions (see Table 5)? |
| 3a | When will you be reviewing your requirements? |
| 4 | Which of the following (list of benefits—see Table 6) do you see as being potentially beneficial to the planning of future land use? |
| 5 | Which of the following issues/capabilities (see Table 7) would you consider useful in a software system aimed at assisting decisions on future land use? |
| 6 | How would you react (see Table 8) to the claim that DSS would provide all the improvements indicated in Q4? |
| 6a | What should the form of the DSS be (options were software product, consultancy or web delivered)? |
| 7 | Approximately how many software systems do you know which provide capability similar to that outlined (in the questionnaire)? |
| 8 | Why might you not consider using a new software system (see Table 9)? |

**Table 2 – Questionnaires sent and response rate by target group**

| Target group | Sent | Response% |
|---|---|---|
| A – Local authorities | 13 | 23 |
| C – Corporate land owners | 5 | 20 |
| E – Rural estates | 9 | 55 |
| F – Financial | 10 | 0 |
| I – Interest groups | 15 | 47 |
| L – Land use agents | 73 | 39 |
| P – National parks and forests | 8 | 62 |
| S – Supermarket owned—farms | 8 | 12 |
| U – Utilities | 27 | 25 |
| O – Other | 7 | 42 |

ket assessment surveys, high technology marketing and small business development.[7] SI undertook a postal survey using a questionnaire designed in consultation with the LADSS project team. The questionnaires comprised 10 questions each with check box options and space for additional comments, see Table 1. The text in square brackets in Table 1 presents the options available or references to the tables in this paper where they are presented. The distribution of 175 individuals sent questionnaires, classified by target group, is shown in Table 2.

The breakdown of the table is interesting as it reflects the view of the development team in 1999 that the tool could not profitably be delivered to individual land managers other than those responsible either for large holdings such as estates, or those responsible for multiple holdings such as land use agents. The overall response rate was 35%, with significant variability around this figure for particular groups. The lower figures in some instances may reflect the relevance of the DSS to their activities, but may also be a result of unsuccessful targeting of appropriate individuals within larger organisations. The overall response rate benefited from proactive follow ups by SI.

7 www.systems-insight.com.

**Table 3 – Responsibilities of survey respondents**

| Area of responsibility | No. (responding) | % |
|---|---|---|
| Management/use advice | 55 | 90 |
| Economic impacts | 40 | 66 |
| Environmental impacts | 39 | 63 |
| Social impacts | 26 | 42 |
| Managing rural estates | 42 | 69 |
| Planning the future use | 40 | 66 |
| None of these | 2 | 3 |

### 4.2. *Market research—results*

To assess the targeting of the survey the first question asked for the respondents' area of responsibility. The responses in Table 3 indicated that the respondents were broadly in the correct domain with economic, environmental and social responsibilities represented.

The next question established which tools and resources were being used and is reported in Table 4. To some extent this met with expectations—high use of personal judgement (95%—though numbers using only judgement were not recorded) and low use of DSS (3%). The use of computer-based tools was significant with spreadsheets and GIS represented at 44 and 34%. This indicates a significant penetration in 1999 of information technology into organisations, yet an insignificant use of tools formally defined as having a decision support role. The absence of software within decision making processes perhaps reflects the reluctance, identified by (McCown, 2002b), of decision makers to cede agency. This reluctance may be reinforced when decision makers lack software or modelling literate backgrounds as it makes judgement-based decisions on the utility of tools very uncertain. In contrast to the low levels of DSS use there was extensive use of external services (34%). This was interesting since it indicates that decision makers recognise the need for additional expertise, since in nearly all cases the services were from specialist consultants. The embedding of DSS tools within consulting services was concluded as having significant potential.

The next question asked for the degree of satisfaction with current tools and resources. The responses (in Table 5)

**Table 4 – Tools and resources being used**

| Tool/resource | Resp | % |
|---|---|---|
| Personal judgement | 58 | 95 |
| Crop yield information | 27 | 44 |
| Spreadsheets | 27 | 44 |
| Other information | 25 | 41 |
| Livestock yield information | 23 | 37 |
| Geographical information systems | 21 | 34 |
| External services | 21 | 34 |
| Other software | 10 | 16 |
| Other | 7 | 12 |
| Decision support software | 3 | 5 |
| None of these | 1 | 2 |

**Table 5 – Degree of satisfaction with current tools/methods**

| Degree of satisfaction | Resp | % |
|---|---|---|
| Very satisfied | 10 | 16 |
| Fairly satisfied | 46 | 75 |
| Fairly dissatisfied | 2 | 3 |
| Dissatisfied with certain aspects | 6 | 10 |
| Very dissatisfied | 0 | 0 |

**Table 6 – Desirability of specific features**

| Feature | Resp | % |
|---|---|---|
| To visualise land use scenarios as computer-based maps | 42 | 69 |
| Faster decision making due to all information in a single source | 37 | 60 |
| Account for social, economic or environmental criteria | 37 | 60 |
| Quick and easy production of alternative scenarios | 36 | 59 |
| Increased objectivity of assessment | 24 | 39 |
| Greater confidence in accuracy of assessments | 24 | 39 |
| Appraise a wide variety of crop and livestock options | 22 | 36 |
| Less fragmented decision making, due to use of single tool | 20 | 32 |
| Improved credibility of decisions | 19 | 31 |
| Other | 4 | 7 |
| None of these | 2 | 3 |

indicated that the vast majority of decision makers were either fairly or very satisfied with current tools and resources. This was interpreted by the market research company as meaning that any venture would face significant competition and would have to demonstrate added-value. The subsidiary question on the likelihood of reviewing tools and resources revealed that 40% would review within 1–3 years, indicating that there was perhaps more fluidity in the market than the satisfaction results alone would suggest.

The questionnaire then offered a range of features to assess what would be desirable to decision makers, see Table 6. The most desirable feature was the visualisation of scenarios, explaining the success of computer-based mapping software, and justifying the author's previous efforts in integrating the DSS and GIS software. Beyond this there was an interesting tie—between multi-criteria assessment (a feature particularly associated with DSS) and single source information provision (that perhaps explains the success of web-portals, such as LaMIS[8] that provide a single source of spatial data such as aerial photography, statutory designations and natural heritage features).

Going beyond these features, the questionnaire sought to prioritise particular issues and DSS capabilities, identified in Table 7. The issues and capabilities identified as most desirable were presentations of information with financial implications, for example public designations (67%), UK/EU grant options (63%) and statutory/legal implications (57%). The desirability

**Table 7 – Issues and capabilities**

| Issue or capability | Resp | % |
|---|---|---|
| Public designations | 41 | 67 |
| Land use plans on O.S./photo-maps | 40 | 65 |
| UK/EU grant options | 39 | 63 |
| Conservation/bio-diversity values | 37 | 60 |
| Statutory/legal implications | 35 | 57 |
| Sustainability | 33 | 54 |
| Impacts on water quality | 32 | 52 |
| Profit and loss accounting | 30 | 49 |
| Profitability: land uses | 30 | 49 |
| 3-D visualisation over time | 28 | 46 |
| Taxation implications | 26 | 42 |
| Investment scheduling | 24 | 39 |
| Productivity: land uses | 24 | 39 |
| Trade-offs between objectives | 24 | 39 |
| Waste management planning | 22 | 36 |
| Labour profiling | 21 | 34 |
| Suitability: land uses | 20 | 32 |
| Optimisation (single objective) | 13 | 21 |
| Other | 10 | 16 |

of conservation/bio-diversity (60%) and sustainability analyses (54%) and impacts on water quality (52%) shows that decision makers are well aware of the wider context against which their management decisions will be judged. There is also perhaps recognition that the necessary knowledge to deal with such issues may not always be available within organisations. What is striking, however, is that there can be a mismatch between issues and capabilities, for example sustainability scores 54% yet the capability to assess trade-offs between objectives scores only 39%. This again indicates that, while there is a desire for more information, there is less desire for analyses that formalise decision making processes. The poor showing of conventional single-objective optimisation (21%) may reflect either antipathy for support tools in general (despite the use of an example of profit maximisation), or just to the concept of optimisation *per se* (since trade-off analysis is nearly twice as desirable at 39%). More generally, SI commented that the desirability ratings for all the capabilities were such that they would not have recommended dropping any from the overall project, but instead that the key features should be prioritised. What is striking is that the capabilities most desired by the respondents are those, that while found in DSS, did not represent what the authors supposed was the *added value* of DSS—analytical tools.

Beyond the issues and capabilities the survey then asked about the likely reactions to claims that a DSS could deliver

**Table 8 – Likely responses to DSS**

| Responses to DSS | Resp | % |
|---|---|---|
| Find out more | 22 | 36 |
| Want to see relevant success stories | 18 | 29 |
| Sceptical | 19 | 31 |
| Tools already developing this way | 3 | 5 |
| Not relevant | 13 | 21 |
| Already adopted | 4 | 7 |
| Other | 2 | 3 |
| Tried but abandoned | 0 | 0 |

[8] www.lamis.org.uk.

**Table 9 – Barriers to adoption**

| Barriers | Resp | % |
|---|---|---|
| None—but cost-benefit decision | 26 | 43 |
| Lack of appropriate budget | 23 | 37 |
| Benefits not significant enough | 18 | 30 |
| Traditional methods preferred | 8 | 13 |
| Needs too specialised | 8 | 13 |
| System should be developed in-house | 5 | 8 |
| Decisions based on external advice | 5 | 8 |
| Other | 4 | 7 |
| Negative previous experience | 3 | 5 |
| No reason | 2 | 3 |
| Staff resistance | 0 | 0 |
| Already have a preferred system | 0 | 0 |

against these capabilities, with the reactions shown in Table 8. From this table it is clear that decision makers while interested to find out more (36%) were sceptical (31%) and would need previous success stories to convince them (29%). This would seem to chime with the experience of (Carberry et al., 2002) in FARMSCAPE where innovative decision makers were interested but there was an initial credibility gap to be overcome. Those interested were predominantly from the agri-businesses and land-agents categories, perhaps seeking a competitive advantage. There was a significant proportion of respondents for which the DSS was not considered relevant but, since there was no opportunity within the survey to say why, it s difficult to interpret this result. Lastly it was interesting to note that there were a small number of respondents that had adopted DSS, and of those none had abandoned then.

As a sub-question to the above the options for service delivery were queried, with a software product preferred by 36%, an Internet-based service by 13% and an external consultancy by 10%. The results of this question again emphasised the desire for control, in this case over the software tool itself. This preference was a serious issue for commercialisation potential since it would have involved a major commitment of resources to build and support a software package rather than delivery via the existing consultancy arm of the research institute. Whether web-based tools would now be more acceptable, 8 years later in 2007 would be worth investigating.

The final aspect of the survey explored the possible barriers to using the proposed DSS. The options and the responses are set out in Table 9. Here as might have been expected, cost-benefits are the key barrier, with an upper limit on the cost of DSS software of £5000 and more typical values of £500–1000 quoted. While these values are consistent with high end PC software prices at the time, they are not, other than at the upper end, consistent with the cost of employing a consultant to undertake an analysis, despite having the software having the potential to be reused for further in-house projects. This confirmed that while DSS may be seen as alternatives to employing consultants the tools crucially lack the credibility to be valued as such. The other significant barriers are that the benefits would not be significant enough (at 30%) and that the decision maker simply does not have a budget for DSS or like software (37%).

The conclusions from SI were that the DSS as specified had many desirable features and little like-for-like competition from existing software systems. Indirect competition (e.g. from consultants) was, however, significant. There was a high degree of satisfaction with current methods and there was a good deal of scepticism that would have to be overcome. The figures for likely income from such a venture (given the low price-per-unit) and the preference for software rather than services (raising the cost of investment in development, deployment and support) combined to mean that as a commercial venture there was little reason to proceed further. This effectively ended the euphoric period for the LADSS team.

## 5. Re-evaluating the role for LADSS

Subsequent re-evaluation of the direction of the LADSS research saw a return to *post-hoc* and *ex ante* policy assessment, one of the core roles of the author's Institute, and one with increasing importance since the establishment of regional government in the form of the Scottish Parliament and Executive in 1999. Agricultural land managers were also no longer the only stakeholders that had to be considered. The policy agenda for land use was increasingly concerned with environmental protection and sustainable rural development and was thus geared to multi-functional (if not post-productivist) land use. These developments emphasised the need to be able to explore and present the trade-offs between multiple, non-commensurable objectives, including financial, social and environmental. The development of the DSS, therefore, continued with a focus on adding multi-objective land use planning tools (Matthews et al., 2000b; Matthews et al., 2003).

The authors' also recognised the importance of the social aspects of decision support, and the team began to look at how the DSS could be embedded within decision making or consultative processes. Such processes are typically organised to promote reason-based debate, termed *deliberation* (Dryzek, 2000) between a wide range of stakeholders with differing perspectives (for example government, agency and NGO representatives) and by so doing, to promote *inclusivity*. These deliberative, inclusive processes (DIPs) have as their primary intended outcome the promotion of mutual learning between participants, with the possibility of reaching agreement between groups if an issue is controversial. The use of aDSS or their outputs within DIPs combines elements of *mediated modelling* and *deliberative evaluation* (Rauschmayer and Wittmer, 2006). A generic framework for the use of DSS as part of DIPs is presented in Fig. 2 and is explained using examples from the use of LADSS in a consultation on CAP reforms in Scotland in 2003 issued by the Scottish Executive.

The DIP has three phases, the pre-workshop preparation, workshop deliberation and the post-workshop analysis. In the first phase the DSS is used to generate one or more case-studies (typically for single land management units) that will form the basis of the deliberation in the workshop. For the CAP-DIP the effect of the policy change options[9] formed the basis of the *status quo* and *impact analysis without adaptation*

[9] The options considered were: *decoupling* agricultural subsidies from particular patterns of land use, the basis on which the payments would be calculated (historic or area based payments), and moving payments from direct subsidy to agri-environmental payments (modulation rate).

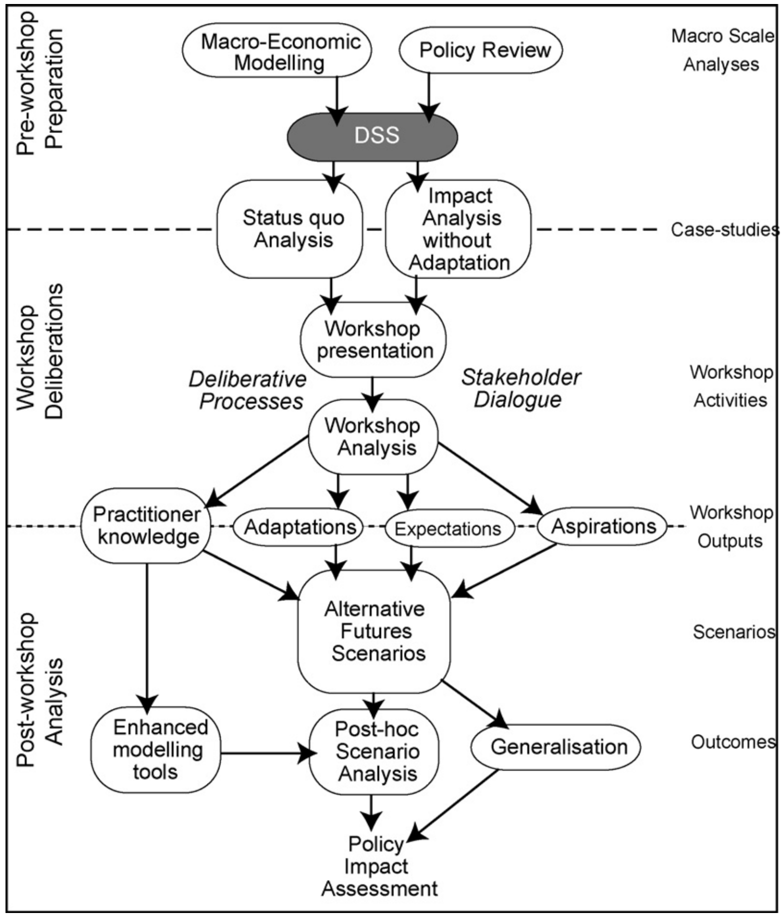


**Fig. 2 – Use of DSS as part of deliberative inclusive processes (DIPs).**

case-studies. The *status quo* analysis is useful in establishing the credibility of the DSS based analysis, by allowing the DIP delegates to compare these with their own experience. The impact analysis without adaptation provides a staring point for deliberation by showing the effects on the case study if there is no adaptive change in management. Both case-studies and the subsequent workshop deliberation are informed by macro-economic modelling and policy-review activities. These analyses are essential to provide a coherent basis for particular case-studies in terms of wider assumptions about the policy and macro-business environment.

As noted in Section 2, the DSS based case-studies act as boundary objects to assist in the two-way communication between participants by making perspectives clear. The case-study may also be viewed as a *neutral space* that is *owned* by the DIP facilitators, giving participants more freedom to explore compromise outcomes. The specificity provided by case-studies, however, also serves to ground discussions within the reality of the particular land-use system and its geographical context (Matthews et al., 2002). This focuses attention on the management levers available and on the strategies for promotion of, or adaptation to, change. The use of case-studies and planning exercises does, however, have a significant time cost that can mean the scope of a DIP is narrower than would otherwise be the case. This is particularly the case given the limits on the domain experts availability (typically one day is acceptable while two or more days begins to become prohibitive).

Within the workshop phase the presentations and deliberations are structured using the case-study examples to capture the aspirations, expectations and adaptations of the delegates to the issues being examined. For the CAP-DIP the deliberations were organised so that the intentions of policy makers could be contrasted with the aspirations of NGO's and the potential responses from land managers in terms of their adaptations to enterprise mix and management. From previous experience with inclusive processes the team were aware that DIPs also provide an excellent opportunity to elicit practitioner knowledge. This often takes the form of heuristics that can subsequently be used to enhance the modelling tools and be incorporated into further formal analyses (typically restricting the set of alternative options that are considered valid). For the CAP-DIP the heuristics were indicative stock-per-person ratios that are both feasible technically and are likely to provide an adequate financial return.

In the post-workshop analysis phase the outcomes of the deliberations are organised into *alternative futures scenarios* to serve as the basis for *alternative future scenario analysis* using the DSS to assess the consequences of the adaptive responses by land managers. Capturing actual adaptation options from land managers is a key outcome of the DIPs since it means that the modellers do not have to make unrealistic assumptions on the nature of behavioural changes. The alternative management adaptation scenarios considered in the CAP-DIP analysis were specialisation, extensification and part-time farming, each with a range of possible, financial, social and environmental impacts at farm and larger scales.

The use of the outcomes of case-study based DIPs as the basis of generalisation remains problematic. While the DSS can generate outcomes on a per hectare or per animal basis, which may be used as a basis for extrapolation, the site and businesses circumstances of particular cases may mean they are a poor basis for generalisation. In any case, generalisation from a few cases is inevitably risky. The use of the DSS to analyse the case-studies does however, provide an opportunity to experiment with the size, enterprise mix and management regimen to test the robustness of assumptions within other models operating at larger scales. The DSS also provides a systematic methodology within which it is possible to compare cases between sectors and regions. The DSS may also be used to fill in missing data from case-studies undertaken for other purposes. Conversely the partial case-studies may serve a validations or calibrations for the DSS using those parameters which were collected.

DIPs have also been used effectively by the authors within the development of LADSS, in particular to test the utility of the land use planning tools (Matthews et al., 2000a). The outputs of the land use planning tools were compared with plans generated by practitioners within a DIP. This allowed the practitioners to comment qualitatively on the solutions derived by the land use planning tools and thus on LADSS potential utility. This resulted in a significant modification to one of the planning tools used as detailed in Matthews et al. (2002). It was also possible to do a post-workshop quantitative comparison of the practitioner and DSS derived solutions. Interactions with the DIP delegates also resulted in significant revisions to the formulation of the land use planning problem being considered (Matthews et al., 2003). The research team were also able to elicit planning heuristics, constraints on management practices and agree the metrics with which scenarios may be characterised (Matthews et al., 2006a).

## 6. Discussion

### 6.1. *The euphoric legacy*

There has been a significant disappointment at the lack success for aDSS, yet perhaps the depth of disappointment is due in part to unrealistic expectations, particularly with regard to the ability of technology to solve problems. The over-selling of technology has been particularly problematic where funders and managers with oversight of projects are not IT literate. This can lead to significant underestimating of the cost of developing and delivering such systems, particularly where aDSS have been sold as an inexpensive substitute for well funded public-good extension services. The ongoing maintenance of tools may not be considered, yet represents a significant cost if upgrades, bug-fixes, help-desks and documentation are to be provided on an ongoing basis. While the use of Internet-based tools has the potential to reduce these costs there are still substantial organisational cost of maintaining a tool used by a significant user base.

The development of aDSS requires IT skills and expertise for which there is significant competition. Software tools, no matter how sophisticated are usually a poor substitute for training in an IT literate discipline. Developers without such skills make errors in specification, implementation, testing and change management that are time consuming and difficult to correct. Another recurring issue for all aDSS is the need to recognise and plan for the provision of input data, and the effect on output uncertainty of using data from varying sources. After all, however well constructed and parameterised the model, *garbage-in* results in *garbage-out*. Standards, computing paradigms and frameworks alone have to date conspicuously failed to deliver simplification of development and deployment process for aDSS. Recent institutional developments in the EU that combine open-source models and data with a sophisticated IT infrastructure of standards, frameworks and model integration engines (Ittersum, 2006) are however, promising. These developments encourage the creating of a community of researchers developing components that can be reused and tested against one another, and integrating such components as necessary for particular aDSS applications. These developments have the potential deliver a coherent and cooperative model and aDSS development community. There remain, however, significant issues of how best to scope and deploy DSS.

In this regard, it may be that aDSS development teams have been deficient by not including social scientists, whose expertise is in studying and facilitating the processes of interaction between researchers and stakeholders. The preponderance of natural science and technology backgrounds in aDSS research has perhaps led to an overemphasis on technocentric development and on narrowly defined modernist objectivity, particularly with what constitutes evidence for evidence-based policy. Social scientists would also provide expertise in best-practice for the necessarily participatory processes of scoping, developing and deploying aDSS. Such interdisciplinarity research and development is relatively rare and can suffer from the same limitations as identified for PAR.

### 6.2. *Socio-political and institutional environment*

The consequences for aDSS of the changing policy agenda have been profound. On one hand, there is a policy agenda and research funders concerned with multi-functional agriculture and changing practitioner behaviour and on the other a financially marginal farming sector with an essentially productivist ethos. Research funded by government and agencies (such as aDSS), that does not improve financial performance or reduce uncertainty will in large measure be seen as irrelevant by farmers since it neither addresses their tactical nor strategic concerns. It is possible to argue that many of the greatest challenges faced by farmers (such as their relationship with the food supply chain and the systems of support and regulation) are problems for which only socio-political rather than research-based solutions exist. The policy and thus research agenda does, however, reflect wider public concerns with the negative consequences of land management for agriculture, particularly concerns about the impacts on natural heritage and human health. In this regard aDSS as part of DIPs provide a possible means of informing stakeholders of the long-term effects of management regimen that are difficult to derive from experiential learning. In particular, they can illustrate changes in slow-change, long-lag, and low-visibility variables and highlight the proximity of thresholds beyond which damaging and potentially irreversible changes can occur.

Institutionally the development of aDSS may have been hampered by research commissioning systems increasingly moving from research sponsorship to a research purchasing model. The *purchaser–provider* relationship is built around a *specify-build-deliver-use* paradigm that has not been successful. The difficulties and failures of the *deliver-use* aspect of aDSS have been evident for some time, with technological solutions failing to overcome the difficulty in getting tool users to invest sufficient time and other resources to master the use of the tool and interpret its outputs. The *specify-build* aspects are also prone to what the authors term the *specification-perfection paradox* (SPP). In the SPP both funders and developers of the aDSS collude in the delusion that any failure could be overcome if only the tools had been better specified. In reality, the sorts of decisions that are being addressed lie within domains characterised by French and Geldermann (2005) as complex or chaotic rather than the known or knowable (with additional data). For the known or knowable domains the specify-build-deliver-use paradigm is tenable but for complex or chaotic domains a co-learning or other inclusive approach may serve better (Gunderson, 2002). Even where the problem is well structured enough and the underpinning science robust, several potential sources of error remain. Firstly there are errors on the developers' part in eliciting the specification. These can be addressed by painstaking and iterative design-build-test cycles, yet the funding for most aDSS projects may limit the project to a single cycle. Even with a well organised and resourced specification process there remain two substantial sources of uncertainty, first user uncertainty about what they want delivered, and secondly developer uncertainty about what can be delivered. The former is compounded when the funder of the DSS development is not the ultimate user. The latter is often the subject of within-project *scope-creep* as users/funders learn and/or priorities change.

One approach to resolving the SPP is to make the tools simpler and more focused. This, however, makes it even more vital to get the specification precisely correct as the resulting DSS will lack flexibility. A longer-term strategy is to build true partnerships between developers and decision makers. In this paradigm each participant contributes their expertise with the aim of developing a mutual understanding of the issues, the capabilities and limitations of the tools and data. The nature of the partnership is one of *capacity building* on both sides. The DSS is replaced as the focus of the relationship by the outcomes of the DSS-based analysis. The development of the partnership paradigm is made more difficult where there is significant staff turnover in, for example in government departments, and where continued funding of activities are subject to lowest-cost competitive tendering.

## 7. Conclusions

From the reviews of DSS implementation, our experiences in developing land-use systems models and applying these in a DSS context and from the market research it is possible to conclude that aDSS are not *necessarily* heading for extinction since they can be relevant to both practitioners and a wider constituency of stakeholders. For practitioners, PAR-based approaches address the key issues of engagement and credibility. The operation of DSS it appears is best undertaken *by* researchers or consultants but *with* practitioners. The coordinated use of aDSS as part of a wider analytical frameworks needs to be considered (with both the tools and processes operating at a range of scales). For the wider stakeholder constituencies, particularly where there is debate or conflict over issues, then using the DSS as a boundary object within a DIP seems to be promising since it serves both to elicit stakeholder knowledge and communicate research outcomes. In both cases, the limitations on the effectiveness of the DSS may depend less on the technical or theoretical aspects of the tools themselves but more on the institutional and socio-political environment that determines issues and resources available.

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