The Decision-Maker has an Important, but Often Neglected, Role in Model Use

J. B. Robinson[a,b] and D. M. Freebairn[a]

[a] *Dept Natural Resources, Toowoomba Qld 4350 (brett.robinson@dnr.qld.gov.au)*

[b] *University of Western Sydney, Richmond, NSW 2753*

Abstract: Although these proceedings contain many papers on simulation and modelling, and a high proportion appear aimed at decision-makers, these decision-makers are rarely identified or discussed. Why? Given that it is the decision-maker, not the model, that manages the real-world system, do we know enough about decision-makers as users of models to be sure that models are used effectively? Maybe not. Decision-makers often behave in ways that seem irrational or biased to scientific model developers. But scientific model developers rarely build models that are flexible, easily used and comprehensive, which is discouraging to decision-makers seeking support. These problem appear to stem, in part, from important differences in the ways model developers and model users view models; the model developers seeing models as instruments for representing the world, while model users want instruments for managing or changing the world. Even though a better knowledge of human behaviour and sociology would appear to be useful to technologists, the evidence to date is that they are disinterested. Seriously disinterested. Why?

Keywords: Decision-makers; Management; Decision support; Knowledge; Bias; Illusions; Intuition

1. INTRODUCTION

Harris [1967] tells a story concerning people, knowledge, and communication;

*"Once, an old farmer, tinkering with a rusty harrow on a country road, was approached by an earnest young man from the University Extension Service who was making farm-to-farm calls for the purpose of selling a new manual on soil conservation and new farming techniques. After a polite and polished speech the young man asked the farmer if he would like to buy this new book, to which the old man replied, **'Son, I don't farm half as good as I know how already'**".*

The book is worthless to this farmer. The young man from the University Extension Service did not understand this because he did not understand the farmer. This is analogous to many, many situations in research, development and extension (R D and E) where there is inadequate understanding between information providers and decision-makers.

This paper examines relationships between the people who produce models and the people who use the models for decision-making. By the means of hypothesis and discussion it explores the potential for people to better utilise the capabilities of modelling and simulation.

1.1 Better Living Through More Modelling - not

While modelling and simulation contribute to knowledge and understanding that may eventually lead to progress, this may be a weak pathway to progress. A common alternative is the direct application of models by decision-makers to management of the bio-physical world. A typical example of this is the use of oil-dispersion models to minimise the impact of oil spills.

Despite this potential, there are signs that research involving models is often primarily for the benefit of researchers rather than for real-world decision-makers, and that modellers, by and large, are not engaging decision-makers in their work. This may not be good.

First, let us quantify some of these assertions about modellers. How often and how much do model developers and researchers engage model users? The proceedings of MODSIM '87 show that 2 of 46 papers (4.3 %) made a significant reference to the users of the models. By MODSIM 97, the rate was slightly higher, with 19 of 324 papers (5.9 %) making a significant reference to model users, and another 11 (3.4 %) making at least a passing reference to them. Besides showing a healthy seven-fold increase in the number of papers published at MODSIM over a ten-year period, these data show that the base level and change in relating the models to the people using them are both very poor. Even if the end-users of models are the modellers themselves, *there appears to be a fascination in model use and little attention to model users*. Except as subjects (eg. in medical simulation studies) **people are largely or totally ignored by more than 90 % of the authors** of these papers. Common sense should tell us that this is not a healthy situation.

A typical introduction to papers at MODSIM includes reference to aims such as analysing, simulating, validating and estimating biophysical objects or conditions. It is not surprising, then, that the conclusions in MODSIM papers also seem to focus on the model rather than either the use or users of the model, or even, in most cases, to the real-world implications of model use beyond the model developers themselves.

Especially common among the conclusions of papers at MODSIM are expressions of the need for future improvements to the models; that they can (or must) be improved in order to make them realistic. It much less common to find conclusions suggesting that a problem has been solved or that models are adequate in terms of corresponding to bio-physical measurements. This begs a question: Do modellers have *a priori* requisite standards of performance? Are these always changing? Why?

Perhaps one reason why modellers are not happy to apply their models or to engage users is because they are discontent with their products, or perhaps they are forever setting higher standards of behaviour for their models. Perhaps the reward systems for researchers is oriented towards development rather than application; it is far quicker and simpler to write a scientific paper than to wade through the complications and tribulations of getting a model used by decision-makers.

Although economic value may be attributed to theoretical papers on modelling, this is contentious relative to estimates of the value of models that are used to produce direct and measurable benefits. Producing foundational "facts" for undefined future decision-making is a vague and unreliable means of achieving positive change. On the other hand, model applications are likely to have much more direct and measurable consequences. In any case, most authors at MODSIMs fail to indicate the end-value of their modelling research to clients, the community or the environment.

2. WHY WORRY ABOUT DECISION-MAKERS?

2.1 Because They Enact Change

In our increasingly pragmatic world, there is little place for models that do not have good linkages to decision-making. Because few models implement change directly via direct control over the real-world bio-physical system, there is demand for modelling that impacts on the human decision-makers. Otherwise, models may have much less practical value in our society.

2.2 Because They Enable Feedback

There is considerable evidence that modellers are greatly assisted in producing more useful and useable systems (a.k.a. "friendly") if they are continuously supplied with feedback concerning the needs of the decision-makers. This feedback needs to be continuous partly because the needs of decision-makers change continually, and partly because modellers are slow to adapt.

The importance of obtaining feedback from model users of all sorts has been iterated many times in a variety of literature, as most of us are aware. However, it is sometimes difficult to engage decision-makers because the overall importance of any one decision is often small to a decision-maker, but great to the modeller. Individuals and small companies tend to make numerous small, unrelated decisions, precluding investment in DSSs that necessarily have limited domains. There may be better opportunities for DSS development at the level of industry or government.

2.3 R D and E Funding is Tied to Change

People or organisations funding modelling are usually interested in seeing positive changes. Improvements in methods and methodologies are usually the lowest levels of achievement, followed by knowledge and attitudes. Material change is typically the most desirable outcome of R D & E.

3. REAL-WORLD DECISION-MAKING

3.1 Strategies and Tactics

A strategy is a plan of action intended to accomplish a specific goal. "Strategy" comes from the Greek word for a general or leader; one whose job is to make good decisions. Generally, strategies are considered long-term and complex, and relate to achieving major goals. For example, strategies in farming might concern purchasing a new tractor (or other equipment worth tens of thousands of $), or growing particular crops (the outcome of which can also dramatically affect profit), or becoming an organic producer.

Tactics are concerned with capturing short-term opportunities. The opportunities and consequences are much less significant than for strategies, and tactics tend to be used more often. For example, in farming, tactics are employed in decisions about buying or selling grain, applying fertilisers and choosing crop varieties

One consequence of the differences between strategies and tactics is that decision support systems (DSS) and research aimed at tactical issues may be less important and less motivating to users than DSS concerning strategies; the tactical decisions have lesser consequences, are numerous, and have lower priorities. This has not prevented some substantial efforts in decision-support that have repeatedly failed due to the tactical nature of the issue. For example, model-based decision support for nitrogen fertiliser decisions by farmers has been the subject of many efforts. Adoption of these systems has always been negligible [Hayman and Alston, 1999].

The importance of viewing models and the use of models from the perspective of the decision-maker rather than the model developer or researcher is paramount (we discuss this further in section 5.1).

3.2 How to Build a Better Strategy

Aids to devising good strategies usually emphasise the process over the content. Strategic decision-making in business is usually broken into steps such as;

- recognising confusion and anxiety
- defining the issue and decisions
- finding and creating useful alternatives
- making trade-offs you can live with
- overcoming obstacles
- developing a success plan
- seizing secondary opportunities
- gaining support for your decisions
- overcoming wishful thinking
- managing setbacks
- affirming your decisions
- balancing your efforts

Unlike the approach of scientists, these decision-making processes are arrived at by trial and error, and are mostly concerned with things that work or appear to work, not just that which appears rational and is well understood. There are also sociological and psychological differences in the two approaches.

3.3 Why Effective Decision-making Processes are Psycho-sociological as Well as Scientific and Technical ?

Sociological and psychological factors are important for decision-makers, at least partly because success depends on external, social factors such as the physical and emotional support of others, and well as internal, psychological factors such as maintaining a balanced and progressive attitude. Also, we are motivated, in part, to make good decisions because they improve our social standing and worth. People don't like to be wrong, so they strive to be right.

3.4 The Role of Technologists

Before large-scale projects progress, they are almost always tested in terms of their science or engineering on a small scale or in a paper-based or computer-based analysis.

It is in the area of testing solutions that scientists, economists and other technological rationalists excel. Most significant problems have multiple alternative solutions, and the various solutions often represent multiple trade-offs concerning costs, time, risk and returns. Technologists' traditional role is to test and rate the alternatives. Modelling fits this role very well.

Figure 1 is a simple representation of technological and sociological traits in decision-making. It also implies that decision-making is more local and specific than the global theories of science and sociology. With respect to the story about the young extension worker and the farmer, the young man would be operating in the top right corner (very general and technological), while the farmer was in the bottom left (very specific and sociological).

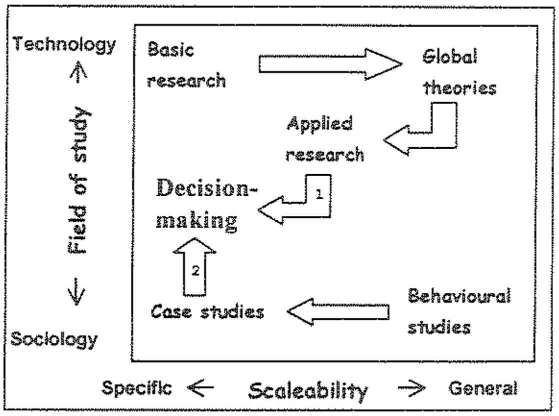

Figure 1. Decision-making in relation to scientific research and sociological studies. The arrows indicate major flows of information, including direct inputs to decision-making from the physical sciences (1) and sociology (2).

4. DISPELLING BIAS AND ILLUSIONS

4.1 How Illusions Work Against Good Decision-making

Illusions work against good decision-making because they promote misconceptions concerning reality. The consequences of different solutions are then miscalculated, and poor choices are made. Illusions may be due to failure of our senses, such as in optical illusions, or in our thinking, which are cognitive illusions. Bernstein [1996] gives examples of whole industries that thrive on illusions (such as the gambling and insurance industries). Modelling that assumes an independent, rational user, and forgets the biases and illusions of model users is aiming far wide of the mark. The commonness and impacts of illusions are shown below in several examples.

Because we have a limited capacity to observe and understand, we always deal with more-or-less real illusions of objective reality. Models can improve these approximations, thus making them more effective and reliable. In extreme cases of mismatch between one person's illusions and a generally accepted version of reality, we easily recognise the delusions, but in subtle cases we may need models to reveal our lack of objectivity.

It is a common aim for model-based research to provide information and approximations that overcome illusions or fill gaps in the mind of the decision-maker. These mental "mistakes" are particularly interesting because they are not only a potential source of poor decision-making, they also highlight the complexity of apparently simple examples of decision-making. For example, Russo and Schoemaker [1989] reported that groups of doctors made different choices concerning a procedure, depending on whether they were told that the procedure was either effective 90 % of the time or ineffective 10 % of the time. A simple change of words and numbers substantially affected the perceptions of doctors, who one would think would be more-or-less unaffected.

4.2 Cognitive Illusions

Cognitive illusions are measured by differences between perceptions and quantitative, objective assessments of situations. Mostly they are due to the limited or biased capacity of people to make quantitative assessments of situations, resulting in reliance on guesses, memory or emotion. Russo and Schoemaker [1989] and Nicholls [1999] describe several types of cognitive illusions, some of which are described below.

Framing effects are caused by the way questions are asked (such as Do you like to eat meat? *versus* Do you like to ingest parts of the bodies of dead animals?)

Thinking is affected by *information impact and availability*, such as a belief that sharks are dangerous, but bees are not, when statistics show the reverse is true.

People tend to stay "fixed" on numbers and ideas, even if they are irrelevant or shown to be untrue. This is known as *anchoring*.

People tend to ignore *prior probabilities*. For example, a thousand-fold increase in the chance of an earthquake today might frighten people despite the fact that the chances of a quake are still minute.

People are often *overconfident* and have *poor intuition*. They also *conform* to other people's beliefs rather than make a judgement on their own. *Groupthink* is a kind of conformity seen among experts and politicians.

Robinson and Freebairn [2001] give examples of cognitive illusions affecting parameter estimation in a simulation model of farm management.

5. CASE OF A MODEL FOR TESTING FARM MANAGEMENT OPTIONS

Figure 2 shows a theoretical schema for a farm. This is not unlike many representations of modelled systems. In this case the policies, strategies and tactics of the management subsystem represent decision-making. However, unlike some representations of systems, the management subsystem is embedded in representation of the biophysical system. In the case of a farm, there are many good reasons for this;

- management is by the farmers, who have non-management involvement in the farm (e.g. providing labour and spending cash)
- the farmer also does much of the monitoring of the biophysical system, often subjectively.

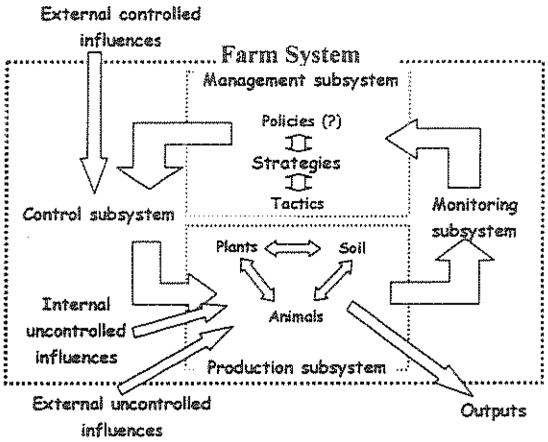

Figure 2. Schema for a farm, showing some relationships between management and production. The arrows indicate flows of materials, energy and information (after McCown [2001]).

5.1 Consequences the 'Farmer Inside' Model

We can see benefits in the "farmer inside" model because it has not always been in vogue. In fact, it is largely a result of farming systems research (FSR), initiated in low-income countries in the 1960s, and introduced to western agriculture in the 1980s. Before this, the predominant paradigm was one of the farmer, farm management system and farm biophysical system being separate and distinct. The failure of this model in low-income countries resulted in the rise of FSR, which emphasises the co-dependence and strong interactions between farmer and farm. FSR has improved the rate of progress in agriculture though integrated problem-solving, more meaningful dialogue, and better alignment of R D and E effort to the goals of farmers and government.

5.2 Benefits of Knowing the Farmer Better

It is important to know the goals and aspirations of the farmer. For example, Frost [2000] showed farmers often had "expressive" values concerning their involvement on the farm. Fulfilment through pride of ownership and a job well done are not characteristic of rational management subsystem; they are attributes of a normal farmer. Conversely, maximising income is a goal often attributed to farmers in economic literature, but this is not clearly observable in real people. Although a sound appreciation of the biases, goals, wants and needs of the model user seems an obvious requirement for successful modelling, it also seems to be often lacking.

5.3 Management as Learning

According to McCown [2001], management and decision-making is not only social, it is local (see Figure 2). Both social and local can be embodied in the term "situated". *Situations are experienced.* Reflections on these experiences are a very important mechanism for ***learning***, which in turn leads to ***improved management***.

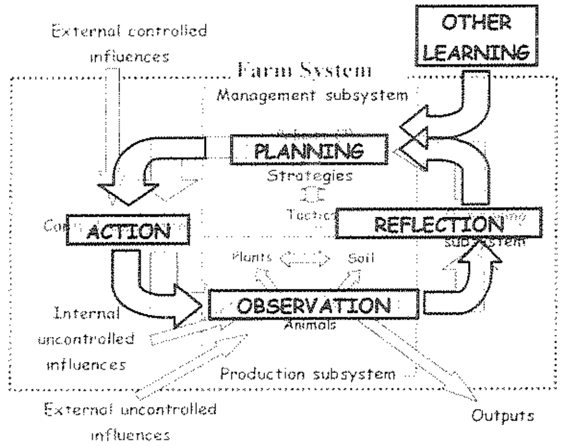

Figure 3. The theoretical schema for a farm (as per Figure 1), superimposed with the action learning cycle of Kolb [1984].

Figure 3 shows some of these ideas. The action learning cycle of Kolb [1984] is overlaid on the schema of a farming system used above. Considering their independent origins, there is a remarkably close correspondence between the elements of the learning cycle and the components of the farming system; perhaps the farming system (real or modelled) may be viewed as a self-organising system for learning and adapting to change. If we imagine for a minute what the consequences of *not* adapting and learning would be for a farming system (or any physical system being managed), it becomes clear that it will eventually become second-rate and perhaps fail.

Although the action learning cycle shown in Figure 3 usually involves a real farming system, there is no reason why it couldn't also apply to modelled farming systems. One could speculate that the same rules concerning survival and adaptation and change apply to the model. Without change the system cannot be self-organising or self-supporting. The principles of learning and improving management seem to be the basis of entertaining games of decision-making such as flight simulators; make the right decisions or you'll wipe out half of Hong Kong! Such pseudo-experiences and the learning obtainable from them fit the theory of an action-learning cycle very well.

In the farming context mentioned above, it would seem important to have a simulator that, like a flight simulator, provided a realistic sense of control, and feedback for good and bad decisions. Unfortunately, except for games such as SimFarm and a few minor examples [e.g. The Fallow Management Game, Hamilton 1995], models of agricultural systems have been oriented to bio-physical accuracy, apparently at the expense of realism in management. This also appears to be true in a substantial proportion of other projects involving modelling and simulation.

Subtle indications of the power of model-based realism in learning management is shown in this SimFarm player's experiences and learnings [http://www.geocities.com/~/simfarm.html];

"You must manage a farm financially and physically (well, in the game anyway) by planting, spraying, harvesting and selling crops, plowing fields, buying land and farm equipment and buildings, managing events, raising cattle and improving your homestead. The best crops in my opinion are: oranges, peanuts, apples, almonds, gladiolas, sunflowers, strawberries, tobacco, rice, and sugar beets. Almost everything else is too much trouble to manage for to little dinero, and you will notice on all the farms that I created, those are the key crops.

Livestock are cool, but a flaw in the game is irrigation ditches make better fences than fences, because cattle can break fences and ransack your fields, but they can't cross irrigation ditches. To raise the quality of livestock, make sure they have adequate food and water, and give them a few trees and a barn to sleep in. Cows will increase by $6 a week if you do this...". A happy learner indeed!

6. SUMMARY

Progress will be made in the application of modelling research by recognising the perspectives of model users and decision-makers.

In other words, the sociological and psychological aspects of decision-making and management warrant attention by model developers and researchers if they expect models to have impact in the real world.

Decision-makers are important in modelling because they are capable of providing feedback concerning designs, issues, relevance, needs and perceptions. They also differ, sometimes critically, from modellers in their perceptions of the bio-physical aspects of the real world or the model.

7. ACKNOWLEDGEMENTS

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