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SWINGS AND ROUNDABOUTS: A CONCEPTUAL MODEL FOR DECISION SUPPORT

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The Agricultural Production Systems Research Unit (APSRU) was set up in 1991 as a joint project of the Queensland Department of Primary Industries (DPI) and the CSIRO Division of Tropical Crops and Pastures. Its mission and research objectives are (APSRU 1991):.

APSRU's Mission

To benefit subtropical Australia and the nation through client-oriented agricultural systems R&D leading to improvements in production efficiency, risk management and sustainability.

APSRU's R&D Objectives

- With the help of prospective clients, to gain a better understanding of how decisions are made, what information is needed, and what opportunities there are for decision support.
- To develop an effective and efficient capability to simulate agricultural production system performance, and use this to analyse risk and evaluate alternative management strategies.
- To provide decision support, and analyses of the impact of production technologies, for clients.
- To demonstrate an effective and reproducible R&D methodology.

The formation of APSRU was a response to the need for improved research methods for dealing with the complex problems of farming systems. APSRU wants to provide a sound basis for improved decision-making in dryland crop production in the region between Clermont, Queensland, in the north of Australia, and Dubbo, NSW, in the south. Through amalgamation of climatic, agronomic, economic and social factors, the research of APSRU and its collaborators promises an improved basis for decision-making and planning for farmers, industry, government and research planners (McCown, Freebairn and Hammer 1992).

The formation of APSRU is based around a core technology: simulation models of crop, soil and hydrologic processes. Agricultural researchers have been working on these technologies for over 20 years (Seligman 1990). Only now do researchers feel sufficiently confident in the behaviour of their models (in the sense that they believe that the models reflect reasonably the behaviour of climate/soil/crop systems) to consider them as tools which can be used to support practical decision-making. The question is, 'How?'

This is not a trivial question. After all, the paradigm in which the original modelling work was grounded is the 'dominant paradigm of operations research' (Rosenhead 1989). Models of crops and soil processes make it possible to research many aspects of crop production by conducting simulation experiments on the modelled system. This is analogous to the development of operations research (OR) in the early post-war period for the management of industrial production processes.

Traditional agricultural research largely ignored the economics of decision-making. (Economics was something that was added on at the end of a research program!) Yet economics has evolved an elegant approach to decision analysis. The core technology of APSRU, the crop simulation model, can generate probability distributions of a performance indicator such as yield in the face of variable weather (especially rainfall). We felt that there was evident scope for dialogue between the researchers constructing the core technology and economists armed with their decision analytic methods. The Climatic Risk Symposium held in Brisbane in 1991 (Muchow and Bellamy, 1991) was proof of this. We were beginning to define an operations research for agricultural production. Operations research is a powerful paradigm that fits well with the experience and way-of-thinking of a crop modelling group. It came as something of a shock to learn that operations research had already been dismissed by systems theorists as an outdated paradigm.

We concede that much of Rosenhead's critique of operations research does apply to the way in which our core simulation technology has been developed:

- The core problem was defined largely in terms of a single objective and optimisation (the words 'optimal' and 'optimisation' are both used in the mission statement of APSRU's parent project within CSIRO).

- Many of the models have considerable data demands.

- Problems of distortion, data availability and data credibility, often associated with experimental data, are also important in modelling work.

- Certainly, the process of model development was scientised and depoliticised in the sense that it was rooted in crop physiology; it was not the result of negotiation except in the very general sense that all scientific 'facts' are social constructs.

- People are not included in the models which are models of plants and soil and water; the decision-maker has not yet been identified.

- Researchers are promoting the use of their models for risk analysis. To the extent that uncertainty has been quantified as risk, it is perhaps not unreasonable to assert that the models could be used to reduce future uncertainty.

These criticisms of technology, and of the process of technology generation, are not new. Even in the mid-1970s, these ideas were in the air (Pirsig 1974; Bradbury, Jervis, Johnston and Pearson 1978). Similar criticisms of agricultural research in developing countries led to the development of Farming Systems Research (FSR) (Remenyi 1985). Farming Systems Research soon came to mean different things to different people, so that by the end of the 1980s even the name was beginning to be abandoned e.g. the International Service for National Agricultural Research (ISNAR) now talks about 'On-Farm Client-Oriented Research' (OFCOR) (Kean and Singogo 1990).

One of the key ideas of FSR, and of OFCOR, was participation by clients (primarily resource-poor farmers) in the research process. This was engineered in two ways:

- by institutionalising an iterative process of consultation with clients (e.g. through Rapid Rural Appraisals); and

- by reinforcing the perceived importance of on-farm research (rather than station-based research). On-farm research was important for two rather distinct reasons:
  (1)to foster participation by clients in the research process, both to capture indigenous technical knowledge and to expose professional researchers to the realities of agricultural production in resource-poor rural communities; and (2) because the behaviour of modern technologies was held to be highly location-specific e.g. new varieties of seed needed to be adapted to local agro-ecological conditions through a program of adaptive research. Farming Systems Research provides another of the legs on which APSRU is based (McCown 1991).

The accusation that the APSRU models are the vestiges of a dying paradigm is not acceptable. This may apply to the way in which some of the core technologies were constructed. It does not apply to the ways in which these technologies might be developed and used by different people in the future. Rosenhead's alternative paradigm for systems research appears to represent better what we are trying to do now in APSRU. We recognise that our models can be used to 'solve' (forgive us - we are new to systems thinking!) problems in different ways. Even in situations where we can define an optimum on the basis of assumptions about what we are trying to achieve and the constraints on its realisation, we are beginning to recognise the contextual nature of these assumptions:

- We recognise the need to seek alternative solutions which are simultaneously acceptable in different ways e.g. yield and soil conservation.

- We are using our system models to reduce data demands, not to increase them e.g. by using our core technology to identify, design, calibrate and evaluate simpler decision aids or heuristics for the management of technological components.

- We are convinced of the need to incorporate socio-economic and agro-ecological data into an integrated framework. The need to incorporate an economic analytical dimension in parallel with, and to some extent to act as a gatekeeper controlling the expression of, the technical model component has been largely accepted by research planners.

- We accept the need to consider the distribution of power in and around decision situations.

- The consequent need for simplicity and transparency is also accepted so that the technology can be understood, and criticised, by people other than professional researchers.

- We are inviting participation in our research by people (growers, consultants, input suppliers) who already own problems with a structure which is amenable to solution in the kind of way which our core technology allows.

- We are looking for congruence between the structure of our models and the structure of problem situations faced by our clients, not assuming it.

- We accept uncertainty, but still maintain that, in the technical areas with which we are concerned, we do know something about the likelihood of alternative outcomes. And that this provides useful information for practical decision-makers.

And yet... What we are suggesting (perhaps naively) is that the dominant operations research paradigm, so maligned when used in other fields beyond the limits of its applicability, has not yet been exploited sufficiently in agricultural production. Our core technology (validated simulation models of biophysical systems) enables much closer integration of biological and economic perspectives. This has been largely lacking until recently in the development of decision support aids. To be most effective, we need to place derivatives of our core technologies within an existing agricultural knowledge and information system in a way that recognises the distribution of knowledge and power. We must not fall into the same trap as mainstream operations research/management science. As Rosenhead suggests to proponents of the alternative paradigm, '... it may be possible to ride pick-a-back on the investment of the optimizers, while subverting their implicit message.' Want a ride? We have started to re-write the message ourselves.

Our conceptual model (figure 1) tries to capture both this openness and self-restraint. We put our simulation models at the centre not because we believe that our conceptual model is inherently techno-centric (even though technology is close to the centre of our world), but to emphasise that what we do only represents a part of the real world (not shown to scale!). The interaction between the process of technology generation at the centre and decision-making processes at the periphery is mediated by a number of screens or gatekeepers, shown in figure 1 as concentric circles (or 'cow pats', Dick Schoorl pers. comm.). We suggest that we need to incorporate a minimum of three screens in our research process:

- the environment, because we need to cope with the issues of the location-specificity of crop response to inputs, and of ecologically sustainable development. Both these issues have a spatial and a temporal dimension. Our program of on-farm research is aimed at understanding the spatial dimension. Modelling of crop and soil processes allows us to consider the temporal implications of different technologies, and to generalise spatially.

- economics, because economic viability is an important aspect of technology design, and economic models of risk assessment are comparatively well-developed. The integration of applied science and applied economics in a common 'techno-economic' paradigm is long overdue.

- sociology, because research is increasingly recognised as a product of social processes. But also because economics does not provide a complete account of actual decision-making behaviour. There is something more. We need to recognise and utilise existing social relations both to get the research process working the way we want and to improve the design of our derivative technologies.

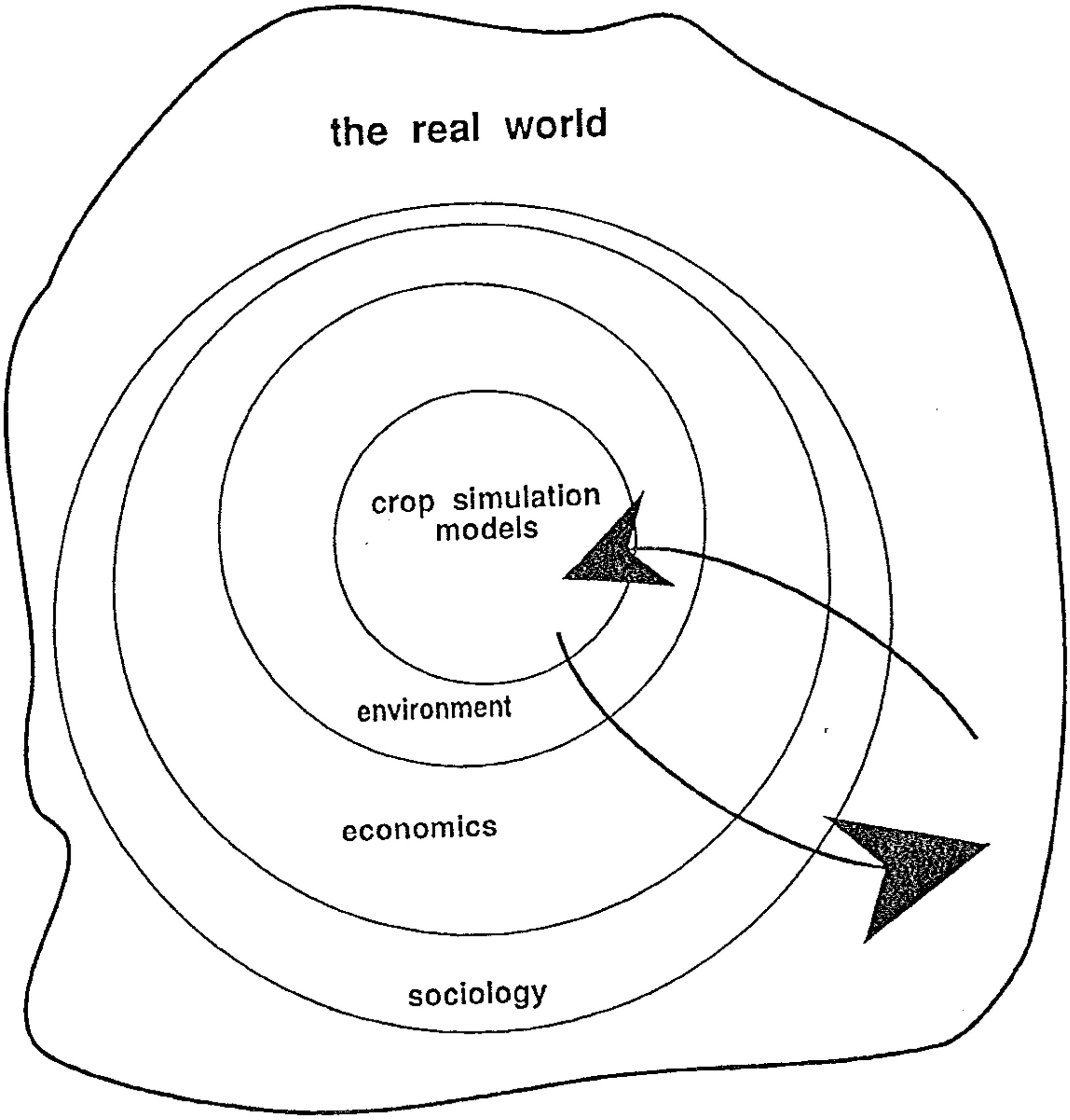

Figure 1. Swings and roundabouts. The roundabouts of sociology, economics and environment act as screens between the real world and the core technologies. The inward swing (from periphery to core) screens the problem. The outward swing screens alternative answers provided by the core technology.

The systems perspective represented by these activities is, in part, a reaction against traditional approaches (in both biology and economics), and an affirmation of the need to consult much more widely than traditional research practice in technology design and evaluation. Although economics might provide a normative model of decision-making behaviour by a hypothetical rational economic man, it is less good at accounting for the actual behaviour of ordinary people with bounded knowledge, limited time for search, multiple objectives (only some of which are quantifiable), and who are members of social groups.

The problem-solving loop in figure 1 connects the core processes with the periphery. The inward swing (from periphery to core) involves progressive screening to identify and structure problem areas which are of social significance, economic importance, environmentally adaptive and which can be ameliorated by the application of our core technologies. The solution (a heuristic, the back of an envelope, a look-up table, an expert system, a social technology?) also needs to be screened on the journey back to the periphery: Is the solution environmentally adapted? Does it make economic sense? Is it socially acceptable and relevant? The swinging is (of course!) iterative and voluntary. At the moment, it is driven by processes operating at the core: the establishment of a new research team. We expect that it will be driven increasingly from the periphery. We have already been approached by people with problems of the kind we believe we can handle (all input suppliers). In other cases (e.g. On-Farm Research), we are still taking the initiative.

Our conceptual framework is similar to that of FSR in many ways: the 'swing' is one loop in Collinson's (1982) figure-eight diagram of the process of technology generation. The roundabouts are an explicit statement of the pluralistic multi-disciplinary approach that characterised early FSR. Similarly, our model can be considered as a collapsed view of the Hawkesbury spiral (Bawden *et al.* 1985). We are all talking about the same thing.

What is new is the way in which we are attempting to articulate the core technology (the 'hard' systems engineering of biophysical systems) with the periphery (using 'soft' systems approaches more applicable in a social context). In our work, the two systems approaches sit right next to each other. The crop simulation models describe the biophysical behaviour of a production system. The nature of the environment of decision-making (location-specificity, sustainability) provides the justification for a model-based approach. An economics model is needed to rationalise resource allocation decisions using data from the cropping systems model.

These three levels of analysis provide a basis for normative propositions both at the individual farm level and at the wider policy level. An understanding of the structure and determinants of actual decision-making behaviour is needed to force relevance in the technologies generated by the hard systems approach, and develop a sense of ownership by the people who will be using them in any technologies that survive the screening process. This sociological screen provides a descriptive model of decision-making behaviour. But it is only from the integration of all four activities that a prescriptive model of decision-making behaviour, one that satisfies the requirements of all gatekeepers, will be generated.

This is described in a more general way by Stephen Covey in his recent book *Principle-centered Leadership* (Covey, 1992). He lists three big mistakes that we commonly make in our attempts to influence others. The first ('Advise before you understand') and the last ('Assume that good example and relationship are sufficient') are particularly relevant. There has been a long history within traditional agricultural research of giving advice without any real understanding of the nature of the problem as seen by the people who own it (Mistake # 1). But conversely, the sociological/cognitive science approach in isolation makes Mistake # 3: it assumes that we do not need to teach people explicitly. Covey puts it this way (p. 129): 'Just as vision without love contains no motivation, so also love without vision contains no goals, no guidelines, no standards, no lifting power.'

In order to overcome both these past failures, we also need to avoid Mistake # 2 ('Attempt to build/rebuild relationships without changing conduct or attitude.') There needs to be a willingness to adapt well-established research practices to new situations where the conditions for their use are not optimal; and to develop new ways of doing research which capture a greater range of perspectives, even if this does mean sacrificing some rigour as seen from the older disciplinary perspective.

We recognise the limitations of the OR paradigm of systems analysis. We are equally impressed with the inherent power and past achievements of the approach. We see a significant place for Operations Research in informing the management of agricultural systems.

We are also committed to the values of Farming Systems Research. The practice of FSR has emphasised the location-specificity of much modern technology and, through its emphasis on participatory methods and on-farm research, done much to show how research can be designed to overcome some of these limitations. But replication of the process of technology generation at many sites is time-consuming and expensive. Our crop simulation models allow us to generalise research results across regions and through time.

This is not an either/or problem: either a hard or a soft systems approach. We need both. We want both. It will only be from the integration of the different perspectives provided by the systems approaches at different levels that we shall know what decisions there are to support, how they can best be supported, and whether it is going to be worthwhile to do it. Such is the potential of genuine systems thinking linked to effective systems practice.

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