CSIRO PUBLISHING
www.publish.csiro.au/journals/ajar *Australian Journal of Agricultural Research*, 2006, **57**, 157–172

Learning from the historical failure of farm management models to aid management practice. Part 2. Three systems approaches

R. L. McCown[A,C] *and K. A. Parton*[B]

[A]CSIRO Sustainable Ecosystems, Agricultural Production Systems Research Unit, Toowoomba, Qld 4350, Australia.
[B]Faculty of Science and Agriculture, Charles Sturt University, Orange, NSW 2800, Australia.
[C]Corresponding author. Email: Bob.McCown@csiro.au

Abstract. Part 1 analysed the difficulties experienced in the field of academic Farm Management in making complex theoretical models relevant to farming. This paper highlights the important connections developed between the field of Farm Management economics and 3 key 'systems' ideas and tools in agricultural science in response to difficulties and opportunities. The first systems approach reviewed is the 20-year experiment by agricultural economists in using crop and animal production simulation models in management analyses. The second systems approach reviewed is Farming Systems Research (FSR), an approach characterised by on-farm experimentation with a management orientation. Many pioneers of FSR were Farm Management economists disenchanted by the inapplicability of economic theory to farm management. The FSR that emerged is interpreted as a scion of the early era of Farm Management prior to the coup by economics theorists in the 1940s. A third systems approach reviewed is a 'soft' intervention to facilitate farmer *learning*. Although evolving from FSR, this approach has surprising similarities to the 'goal adjusting' consulting performed by the legendary Australian Farm Management consultant *cum* academic, Jack Makeham. The paper concludes with discussion of a recent innovation that combines these 3 approaches. It uses a soft intervention approach that features farmers shaping their goals and expectations by 'experimenting' in a local, but virtual, environment provided by simulation of the production system using 'hard' models.

Introduction

The history of Farm Management (FM) is extraordinary in both its duration and its substance. Since the establishment of the Office of Farm Management in Washington, DC, in 1902 until recently, there has persisted a professional field aimed at providing support for farmers in operating farms as businesses. Part 1 of this series (McCown *et al*. 2006) dealt with the rise—the 'takeover' of the field from agricultural scientists by agricultural economists who claimed that economic modelling was essential to the future of the field—followed some 3 decades later by the demise, characterised by admission by leading agricultural economists that the models had proved to be inapplicable (Dillon 1979; Malcolm 1990).

Our main aim in this series is to understand this failure and to suggest a way forward. For our inquiry, we have adopted the structure used by Malcolm (1990), who reviewed four, largely successive, modalities of FM thinking and practice: production theory, activity analysis/mathematical programming, decision analysis, and systems approaches. In Part 1 (McCown *et al*. 2006), we looked at the performance and developments within the first 3 of these approaches. For further structure we drew on the insightful dichotomy created by Schultz (1939) who distinguished between *planning* and *expectation formulation* in the management of farms, and the claim that the importance of the latter greatly exceeds that of the former. Consequently, in Part 1, we hypothesised that 'late era' FM has been mistakenly preoccupied with intervention to provide theoretically rational plans when the greatest need of farmers in their planning and decision making, is support in forming more realistic expectations. In this second and concluding paper, we pursue Malcolm's FM fourth theme by examining 3 very different systems approaches and the possibility that their limitations are reduced in an approach that combines them.

The earliest of these systems connections to FM is 'systems analysis and simulation'. This was seen as a means of enhancing farm models, especially by enabling dynamic treatment of production system processes instead of static 'production functions'. Dent and Anderson (1971) pioneered this experiment in systems analysis and simulation. Their book in 1971 brought together various scientific modelling efforts into a farm management economics perspective. Although for Anderson, this digression was temporary, for Dent, it was the start of a new 'systems' career path. In the present paper, successive updates on views and activities

 10.1071/AR05052 0004-9409/06/020157

of Dent and his students provide a significant resource for tracking trends in systems approaches in FM.

The second 'systems' strand is that of Farming Systems Research (FSR). Instead of being a *reform within* FM, FSR is, in 2 respects, a *scion of* FM. First, a large proportion of the pioneers of FSR in the 1960s and 1970s were 'refugee' economists from FM. Of these, the person most central in our story is John Dillon, who underwent a late-career 'systems' conversion experience (McCown *et al*. 2006). Second, early FSR tended to resemble 'early era' FM, with its on-farm, consultative, research approach (Norman 2000).

The third connection between FM and 'systems' centres on Jack Makeham, a farm management consultant-turned-academic, whose approach to intervention both Dillon (1979) and Malcolm (1990) singled out as especially successful. Makeham described himself as 'a professional goal adjuster' (Makeham 1965). This was a rare instance of formalised FM intervention practice that featured facilitation of expectation formulation in management instead of theoretically rational planning.

The final section sets out a logic of combining key aspects of these diverse systems approaches: situated simulation modelling, on-farm research, and facilitation of farmers' formulation of expectations. The logical case for this combination is augmented by brief reference to an actual case of such an eclectic systems approach that has been evolving for over 10 years.

Simulation of farm production systems and their management

By the late 1960s, Anderson and colleagues were calling attention to serious inadequacies of 'response analyses' that used simple, static *production functions* for representing relations in the Production System (Fig. 1) between certain controllable factors and outputs (Anderson 1968; Byerlee and Anderson 1969).

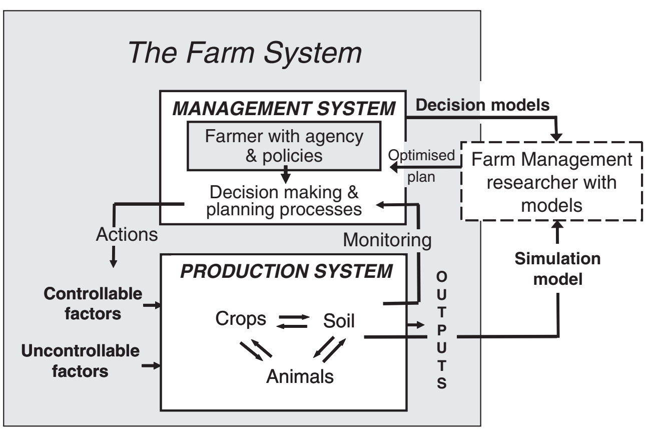

Fig. 1. The farm abstracted as a humanistic *management* system cybernetically linked to a biophysical *production* system (after Sorensen and Kristensen 1992).

At about this time, simulation models of production processes were emerging from research in various disciplines in agricultural science, having been stimulated by modelling in Operations Research 2 decades earlier (McCown 2002*a*, p. 13). With reference to Fig. 1, this section examines the 20-year 'experiment' in using simulation models of the Production System, together with decision models of the Management System, to provide rational plans for farmers. The focus is on 'if' and 'in what way' better production system models overcame past impediments to realistic analyses.

Our starting point is the assessment by Dent and Anderson (1971) of the potential in FM for the simulation models that were appearing in various fields of agricultural science. Even today, 35 years later, their arguments for investing in simulation, the identification of general problems, and speculation on development pathways remain salient. Anderson and Dent (1971) concluded that in all but one of the cases, what made the choice of simulation compelling was the inherent complexity of management resulting from multiple dynamic interrelationships and the pervasive influence of stochastic factors. They foresaw that the major benefits from models so enhanced 'must stem from the improvement in decision-making about the real system following experimentation with the model' (p. 387). The major challenge in achieving this was improving the capability of models to credibly mimic system performance. In addition to enhanced models, this would depend on overcoming the high costs of specifying models for sites/enterprises of actual farms. They had reason to believe that the model *development* enterprise would flourish, driven by incentives of scientists and institutions quite distant from improvement of farmer decision-making. But they were concerned by the infeasibility of applying models to specific sites and enterprises. They imagined

> '. . .the possibility of establishing autonomous modules representing relationships that apply with acceptable accuracy over a region. Such modules may then be linked together so that they form the core of a model; to this core, the unique characteristics of the overall system to be modelled may be added. These additional sections often will be constructed relatively easily and quite simply linked with the selected modular core. The behaviour of the complete model then can be examined in relation to the specific environment that prevails for the problem' (Anderson and Dent 1971, p. 388).

Over the next few years, Anderson (1972, 1974) critically and comprehensively reviewed the field of simulation methodology and application in farm management economics with the focus on 'the interpretation of output for managerial decision making'. Anderson (1974) saw problems falling into 2 categories of relationships: between the model and the real world and between the researcher and the farmer. Whereas the former was a matter for biophysical modellers, the economist had something to say about the latter:

> 'It will be useful to introduce the idea of a manager or decision maker charged with the responsibility of interpreting the output from a model constructed by a [systems scientist] in his employ. [ ] The [systems scientist] is asking the manager if one [output probability] distribution is in some sense better for him than another' (Anderson 1974, p. 26).

The dual challenges of good models and affordable specification/customisation for actual sites/enterprises identified by Anderson and Dent (1971) have since dominated research in this area of FM. In the quest for model credibility, a major challenge for modellers was to ensure that models were sufficiently sensitive and comprehensive to adequately mimic behaviour of the production system, yet remained sufficiently small and simple to be easy to understand and affordable to maintain. Deficiency in a model's ability to mimic production processes takes 2 forms (Thornton *et al*. 1991, p. 331). The model can possess inadequate *sensitivity* to small changes in input conditions that are important in the real world. Alternatively, the model may omit entire processes that are important in an application in the real world, i.e. it may have inadequate *comprehensiveness*. In either case, an enhancement almost always involves elaboration of the model, and elaboration increases costs (additional and/or more expensively obtained data, increased software complexity and maintenance costs, reduction in comprehensibility, etc.).

Customisation to a specific farm situation contained issues of both models and data. Charlton and Street (1975) explained that although they would have preferred simpler models of both financial and production aspects of pig and dairy enterprises,

> '. . .simple models would have been incapable of being applied to a specific farm problem. The complexity of the models arose not from the introduction of sophisticated relationships but *from the need to provide detail and adequate flexibility*' (Charlton and Street 1975, p. 262; emphasis added).

The conflict between process elaboration in models and the feasibility of their use in practice has continued to be a perplexing issue. The focal point for a great deal of research attention became how to make it cost-effective to customise models for a specific farm. Blackie and Dent (1974) considered the following 2 approaches.

> 'The first involves the development of a 'representative' farm or enterprise model which can be used to examine the effects of differing management policies. This type of model is largely confined to examining the implications of major management changes. The results from such models cannot be applied directly to an individual farm and therefore are unable to provide specific management guidance.
>
> The second approach relates to the construction of a 'skeleton' model which represents the logical structure and includes only the basic parameters of the real system. Such a model becomes functional only when 'coupled' with data from an individual farm and, in its 'coupled' state, is unique to that farm. The model must be capable of reflecting both the sequence and timing of feasible decisions in order to reflect individual management policies. Systems may appear similar except with regard to their detail; the model must have the capability to adequately distinguish and mimic all such systems' (Blackie and Dent 1974, p. 166).

These authors saw private consultants as important facilitators in generating farm data from individual farm information systems, with farmers acting to update these systems through low-cost enhancements of their normal monitoring of the production system and the external environment. In 1975, in a review of systems applications that featured skeleton models and coupled information systems, Dent confidently predicted the application of skeleton models for management purposes on individual farms 'in the not too distant future' (p. 123). Development was at an advanced stage for pig and dairy enterprises, but

> 'To be operational, the information system, in which the skeleton model is embedded, requires considerable investment in carefully designed computer systems and in extension effort to introduce farmers to the information systems and to oversee its operation' (Dent 1975, p. 123).

Four years later, Dent and Blackie (1979) still saw farm management information systems containing skeleton models as pivotal in the links among basic research, applied research, farm systems, and industry and government policy (fig. 7.8, p. 171). But by this time their emphasis had shifted strongly to the *information* component. They judged that the financial burden of farm data collection and storage was best shared with industry and government who, it was argued, needed this information for policy and administration. The CANFARM management information system (MIS) in Canada was held up as an innovative venture with relevance to both farmers directly and to public administrators. But contribution of *simulation* to management of farms was still 'hoped for' within the MIS program:

> 'The role of information systems in gathering production statistics about farming or farming systems has been outlined. . ., and if many farmers are involved in an information system, this surveillance leads to the possibility of gathering aggregate current production statistics on a scale not previously possible and on a time scale hitherto unachievable. The availability of such aggregate data has immense potential from a farm policy point of view either by government or by commercial firms. In either case, agricultural extension agencies are bound to be influenced. But it would be hoped that the major impact on extension would be by the way of the information system permitting [customised simulations that aid] (*1*) planning of farm strategies to meet the objectives of the individual farmer; (*2*) controlling the farm business both biologically and financially' (Dent and Blackie 1979, p. 172).

Although no explanation is given, both CANFARM and the skeleton model saga seem to have ended at about this time, without affecting the issue of site-specific relevance. Two decades later, Carberry *et al*. (2002) confirm that the site specificity sought by using skeleton models may often be a necessary condition for making simulation meaningful to a farm manager.

Anderson (1974) proposed 2 logical strategies for addressing the problem of relevance of models to farm situations. One was to make the FM model more like the farm. Applying his views to Fig. 1, the key to achieving relevance to management of the model of the Production System may lie in the specification of the model of the farmer in the Management System. Clearly the chance of model outputs crossing the threshold of relevance would be enhanced by direct elicitation of the real decision maker's views of the world (Anderson 1974, p. 34). The second strategy was to encourage farmers to behave more like the models:

> '. . .the practical value of the theory in decision analysis depends upon the feasibility of convincing real-world managers of the merits of a systematic approach to their decision problems and on their assessments of the relative costs and benefits of systematic vs. intuitive decision making' (Anderson and Hardaker 1972, p. 171).

Twenty-five years on, these 2 strategies remain central to intervention in farming practice using simulation models (McCown 2005). In theory, Anderson (1974) showed that these 2 strategies could be pursued by using decision analysis, but in practice he still regarded the relevance gap as an enormous challenge. The 2 components of Fig. 1, the production system and management, could be represented, respectively, by a simulation model and decision analysis. The output was a formal solution to an important, but abstracted, problem, to be made available to interested managers. In summary, Anderson introduced the notion of dialogic interaction between farmer and a professional with a model (Fig. 1), but took it no further than a *metaphor* to aid structuring of data collection for formal optimisation and generation of notionally 'best' plans.

In their closing remarks in the 1971 book, the emphasis of Anderson and Dent had been on enhancing and demonstrating model competence in simulating farms and farming. By 1974, Anderson was departing the field, and his emphasis was on the relevance gap between the situated practice of a farmer and the scientist's recommendations of theoretically best practices:

> '[The] problem that pervades all modelling in systems work, and not just simulation, concerns the relationships between the modelling and the real world, and between the modeller and the real world decision maker. Focusing on simulation, it seems reasonable to conjecture that a considerable majority of studies have received little or no acceptance by real-world decision makers and have had little or no impact outside professional circles. Presumably the chance of a [modeller's] conclusions *crossing the threshold of relevance to have an impact on real-world decision making* depends crucially on the acceptability and accuracy with which he conceptualises his model of the real system and the way in which he presents his model and his results' (Anderson 1974, p. 34; emphasis added).

Modelling of a farm had progressed to where there was a real prospect that simulation combined with decision analysis in FM could mimic the crucial time-dependent behaviour of a specific management system of a farm. But there were numerous barriers to reaching Anderson's 'threshold of relevance', which were to continue to occupy attention of economists and scientists for the next 3 decades.

The 1990 symposium held in honour of Prof. Colin Spedding's contributions to the field of agricultural systems provided a significant opportunity for assessing progress of the 'simulation-for-management-intervention experiment' during the 1980s (Jones and Street 1990). But the scope of economist-supported intervention was spreading from economic analysis for allocation of scarce land, labour, and capital resources to including supporting technical control of production processes in uncertain environments (e.g. Dent and Thornton 1988; Thornton and McGregor 1988). Progress during this period can be viewed as (*a*) improvement of the competence and comprehensiveness of models to simulate the production system, i.e. *research*, and (*b*) contributions to improved *intervention* in management decision and planning.

In the 1990 symposium, it was evident that after more than 2 decades of trying to improve farm management using bio-economic modelling, previous cohesion based on collective optimism was disappearing. On the one hand, Bywater (1990) was upbeat, displaying 6 pages of 'examples of models which might have applications at the whole farm or whole enterprise level [in providing] a vehicle for assessing a range of management considerations. . .'. These covered cattle, sheep, pig, poultry, crop, and mixed crop and livestock enterprises. The comprehensiveness with which farming systems could be notionally simulated had increased, and Bywater observed that the 'use and usefulness of production system models are increasing' and that 'if modelling and model use have not come of age, then they are certainly well on their way to doing so'.

Other contributors were disparaging of the lack of effect and prospects for effect of modelling on practical farm management. However, there was no unanimity concerning causes and promising remedies. Dent (1990) lamented the failure of models to approximate the purview of real farming, and concluded that this was due to over-investment in models of the Production System and under-investment in models of the Management System (Fig. 1). 'Trivial' resources had been spent on the determinants of the behaviour of the farm family with respect to consumption, investment, risk, and 'the equally important social parameters including attitudes, values, traditions, peer group pressure and culture' (p. 126). The gap was an unsatisfied need for holistic, but still *prescriptive*, intervention; more comprehensive systems research was required to provide these.

To Dent, the degree that research in the on-farm practice situation is ineffective is due to failure of the research practice to be sufficiently organised and scientifically rigorous:

> 'The whole process of what has been termed 'adaptive research', whereby developed and tested technology goes through a process of adaptation, evaluation and adjustment in real farming situations before the adoption process becomes effective, appears to be without the accepted professionalism of agricultural research. Linkages between extension agents and scientists are informal and the experiences of advisers are not reported in the research literature' [and hence are not subjected to public evaluation] (Dent 1990, p. 126).

This 'broadside' was directed at the on-farm experimentation of FSR (following section) for its perceived lack of scientific rigour. In terms of Fig. 1, the rigorous systems approach that Dent envisioned would have models of the *production* system and *management* system so comprehensive that they would provide a basis for policy on technology development to fill gaps:

> 'In a holistic sense, however, technology should be developed only in relation to the farming systems in which it will play a part: knowledge of the potential impact on enterprise systems, farm household systems, and therefore, potential adoption rates should be assessed in advance' (Dent 1990, p. 126).

Subsequent publications by Dent and colleagues featured comprehensive descriptive research on farm households (Austin *et al*. 1998*a*, 1998*b*; Willock *et al*. 1999*a*, 1999*b*), but they do not reveal relationships concerning management behaviour that might enable anything like 'potential adoption rates [to be] assessed in advance'. There is certainly no evidence of any new research paradigm, the absence of which concerned Dillon (1979, p. 12), if 'mere description' of households was to be avoided.

The critique by Doyle (1990, p. 107) was no less harsh than that of Dent. He bemoaned 'the failure of systems concepts and simulation models to have any practical impact on farming', and identified 2 main reasons: the failure of researchers to liaise with farm decision-makers and the preoccupation of systems researchers with model building rather than application. However, unlike Dent (1990) and Malcolm (1990), who argued that the relevance 'gap' resulted from insufficiently comprehensive models, Doyle (1990) argued that pursuit of comprehensiveness was impractical. The problem was not that models were too 'partial', but that they were not partial enough. He advocated the scaling down to target problematic *aspects* of farms and their management:

> 'The very complexity of biological systems and their susceptibility to unplanned variations make it difficult to design adequate representations of the real world. Nevertheless, the systems approach to analysing processes and resource decisions on farms potentially opens up the prospects of using models as aids to control of individual farm processes' (Doyle 1990, p. 108).

This simpler approach to using models was characteristic of the Decision Support System (DSS) that had come to prominence in agricultural research during the 1980s (but was to have similar problems in 'crossing thresholds of relevance' in farm decision making) (McCown 2002*a*).

Farming Systems Research, its links to Farm Management, and the evolution of a 'soft', participative research and intervention paradigm

Dillon's disenchantment with theory-based FM resulted from his conclusion that it was 'inapplicable' to the management of farms. There was a need to be 'oriented better to the realities of the whole farm system and its management problems' (Dillon 1979, p. 12). The primary need was for the essential technical and business aspects of farming to be treated in the unique local physical and human contexts. To Dillon in 1979, the farm was a '*dynamic*, *open*, *stochastic*, and *purposeful*' system and farm management activity must somehow be treated as practice that was essentially *social*.

The most feasible platform for designing professional intervention in such practice appeared to lie within the 'systems' paradigm:

> '...in arguing that FM has become too oriented to research techniques and theory rather than problems, some critics mention the need for a multidisciplinary basis to FM and a focus to farm-household relations. However, they present no paradigm in which to orchestrate such a development. My view is that systems analysis constitutes such a paradigm – at least until the next revolution comes along' (Dillon 1979, p. 12).

However, there was no confusing the systems approach envisioned with that of 'systems analysis and simulation':

> 'I see no quick resolutions in terms of fancy mathematical or computer modelling – the farm system and its management are too complex and human for that' (Dillon 1979, p. 12).

This ideal of 'holism' was so fundamental that diagnoses of the crisis of relevance in FM centred on the failure of analysts to model sufficiently comprehensively the 'whole farm' (Dillon 1979; Malcolm 1990, 2000). The models of agricultural economists were whole-farm models in the limited sense of analysing the competition for resources across the production system, but a far broader approach to holism was required to capture the social dimension. In Dillon's words:

> 'As yet, there is no significant body of principles relating to the non-technical, non-financial elements of farm systems, little factual data is available, and methodologies for studying these components are generally lacking. The research need is great but prior conceptualization is necessary to get beyond mere description' (Dillon 1979, p. 12).

FSR adopted the revolutionary strategy of taking the research into the social practice situation. The significance of this seems to be captured well in the 'swamp' metaphor of Schon (1983):

> 'This dilemma of "rigor or relevance" arises more acutely in some areas of practice than in others. In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing "messes" incapable of technical [or analytical] solution. The difficulty is that the problems of the high ground, however great their technical [or theoretical] interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern. Shall the practitioner stay on the high, hard ground where he can practice rigorously, as he understands rigour, but where he is constrained to deal with problems of relatively little social importance? Or shall he descend to the swamp where he can engage the most important and challenging problems if he is willing to forsake technical [or analytical] rigour? [ ] There are those who choose the swampy lowlands. They deliberately involve themselves in messy but crucially important problems' (Schon 1983, pp. 42, 43).

FM economists who pioneered FSR in the developing world left the high ground and entered the swampy lowland of professional practice. Although it was not initially clear just how practice should change, a new, adaptive approach did evolve. It began, more than a decade prior to Dillon's 'conversion experience', in Asia, Latin America, and Africa during the 1960s and early 1970s. Western FM economists working in smallholder agriculture became progressively disenchanted with their training and tools (Norman 2000; Norman and Matlon 2000). There was a turn towards greater *engagement with farmers in their situations* as means of ensuring relevance of research and intervention.

The nature of the approach that emerged has recently been described by Norman and his contemporaries, 'revolutionaries' who had been trained in the theoretical approach of the 'late era' of FM, but the approach that evolved in response to failures was

> '...based on the premise that one had to begin with understanding of the problems of farmers from the perspectives of farmers. Solutions had to be based on a proper understanding of their objectives and their environments, including both biophysical and socioeconomic components' (Norman and Matlon 2000, p. 25).

In the epigraph to another paper specifically about the influence of FM on the farming systems approach, Norman (2000) declared that

> 'Philosophically, the ... farming systems approach, as practiced mainly in low income countries, has much more in common with

the 'earlier' farm management approach in the high income countries' (Norman 2000, p. 293).

Norman's positioning of this as an epigraph highlights the irony that as a farm management economist trained in the theory and methods of the 'late era' of FM, he nevertheless found that the key to achieving relevance to the management of farms was to return to the commonsense approach of the *early* FM era, an approach thoroughly discredited by the mentors of Norman's generation for lacking a theoretical basis (McCown *et al*. 2006).

One widely reproduced representation of the farming systems approach was that of Collinson (1982) and shown here in Fig. 2. Using this flow diagram, several important features of this research approach can be highlighted: (*a*) it has a focus on technological change rather than improved business management, (*b*) it is oriented to solutions of farmers' problems, and (*c*) it embeds 'systems' concepts of the day and foreshadows some of the future.

Technological change

The focus of late era FM research and intervention was on resource allocation for production, *given* the technology; the focus of agricultural science, on the other hand, was on the economic benefits of technological change to the production system. By the 1960s, some agricultural economists were recognising that the major increases in farm incomes were attributable mainly to such improvements. Dillon (1979, p. 12) applauded the successful consulting strategy of Jack Makeham, which placed top priority on dealing with 'how to incorporate new technology profitably'. At the same time, FM economists from high-income countries were studying smallholder agriculture in low-income countries and were concluding that farmers 'were rational (i.e. economising) in the methods they used' (Norman 2000) and, although farm households were often poor, they were generally *efficient*

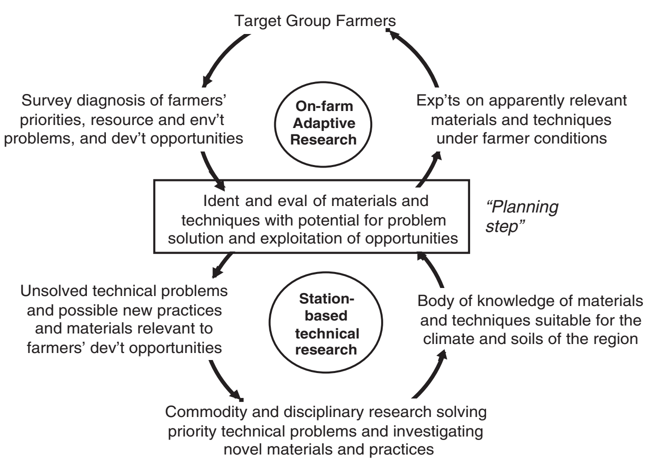

Fig. 2. Schema for Farming Systems Research of Collinson (1982).

in resource allocations (Schultz 1964). In contrast to their traditional stance, FM economists were now arguing that the best opportunities for improved farm performance lay in improving technology.

Although the core of the change process implicit in Fig. 2 is new technology, what most characterises the approach is the extent to which research activities depart from 'tradition', in that relevance to farms, farmers, and their problems is primary. The process 'begins and ends with the farmer' (CIMMYT 1980) rather than with theory held by the professionals.

Solving farmers' problems

The implicit logic of the research process in Fig. 2 concerns a problem-solving process made up of 3 stages: diagnosis, planning, and testing. The problem solving takes place in 2 complementary research environments forming 2 intersecting 'loops'. The first loop represents the researcher's interaction with the farmer and the farm. The second loop is that of the researcher's interaction with sources of research capacity and products, located in the 'research station' but later broadened to include many other important sources of 'materials and techniques' (Collinson 2000, p. 393). Part of the, so-called, 'planning step' that links the 2 loops, is the judgement as to whether the materials and technical practices needed on the farm are available or need to be developed. If the latter is the case, then specifications need to be given, based on diagnosis at the farm level, for development or acquisition of these.

Engagement with the farmer concerning practice was the strategy for ensuring relevance of scientific intervention. In Fig. 2 this takes place both at the problem diagnosis stage and in final on-farm testing of innovations. In the FSR collaboration between agricultural scientists/technology developers and agricultural economists, the latter assumed the role of managing the interface between farmer and the researchers (Collinson 1982).

Systems concepts and paradigms

Figure 2 contains the, then, contemporary theory of management of designed, purposive systems, strongly influenced by Herbert Simon. Simon (1966) had comprehensively critiqued the theoretically normative approach that was central to late era FM and successfully advanced an alternative *behavioural* approach based on learning from managers' demonstrably successful behaviour (discussed in Part 1 of this series, McCown *et al*. 2006):

> 'The task of a comprehensive *logic* of action is to describe or prescribe the [actor's] rules that govern current reasoning about the occasions for action, the discovery of action alternatives, and the choice of action. [The] starting point is to ask what the practitioners actually do. [ ] By examining their reasonings, we shall perhaps

> be relieved entirely of the task of constructing a new logic of norm and action: at worst, we shall have to make explicit what is implicit in practice, correct it, and improve it' (Simon 1966, p. 1).

Okali *et al*. (1994) took this 3-step 'logic of action' of Simon's that is contained in Fig. 2 to be the underlying structure of *all* agricultural research:

> '. . .research, whether formal, or informal and involving scientists or farmers, will be considered to be a more or less deliberate and systematic process that proceeds through three general stages: (*i*) identification of opportunities (perhaps more commonly referred to as problems or constraints), (*ii*) identification of ideas or options and (*iii*) testing and/or adaptation of the ideas and options' (Okali *et al*. 1994, p. 13).

Collinson elaborated on the first, *diagnostic*, step in this approach:

> 'A Farm Systems Economist [FSE] attempts to understand how a farmer allocates his scarce resources of land, labor, and cash between crop, livestock, and off farm production in a manner which best satisfies his and his family's priorities. This is essentially the economic problem. The FSE's professional task is to understand a farmer's decision criteria, and to identify how and why, in managing his farm, the farmer compromises on the optimal technical management of any one enterprise in order to raise the productivity of the whole system' (Collinson 1982, p. 3).

Okali *et al*.'s third step of testing focussed on value to the farm family and operationalised the ideal of a holistic, 'whole farm', approach that was assumed to be needed if relevance to farm management was to be achieved (e.g. Malcolm 1990, 2000).

In the application of these 3 aspects of FSR (i.e. diagnosis, assessment of options, and testing), 2 other significant aspects became apparent. These were a marketing orientation and engagement of farmers in the research process. The significance of the marketing orientation, as well as its progressiveness, was indicated by Roling (1988). In lamenting the failure of agricultural extension, generally, to learn from the marketing research tradition, Roling observed that

> 'Farming Systems Research, a systematic procedure closely following marketing research routines, to develop and test 'appropriate' agricultural technology with client populations has so far not been widely adopted [in extension]' (Roling 1988, p. 30).

Moreover, the relationships of researchers with farmers in early FSR went beyond study of client practical behaviour to client engagement in the process of research:

> 'Farmers' needs and circumstances are always specific to local situations. Relevance in research demands that local farmers provide their own perspectives in planning experiments and their own decision criteria in evaluating the results. FSR attempts to understand the way farmers make decisions and *it encourages farmers to participate in the research process*. FSR has the capacity to strengthen linkages between researchers and their small farmer clients' (Collinson 1982, p. 3; emphasis added).

Thus, the early FSR, led largely by economist refugees from FM, created an approach to research and intervention that differed radically from the FM in which they were trained: interventions were aimed at improved technologies rather than more efficient resource allocation plans; intervention was based on solving local problems rather than applying theory to routine practice; reference criteria for identification by professionals of best practice were those of good farmers rather than theory about the market; and farmers began to be co-researchers as well as target clients.

In analysing the paradigm change in the FSR experience, we have used the distinctions between 3 paradigms for scientific intervention in farming practice outlined by McCown (2001). FSR began by breaking with 'late era' FM and the latter's *normative* paradigm of theoretical design of plans or 'best practice' for farmers. Instead, research and intervention in FSR was strongly guided by observed behaviour of successful farmers in real farming situations (a *behavioural* paradigm). Although developed more fully later, there was a tendency towards inclusion in the research process of the farmer with his/her subjective purposes and practical theories of action based on experience (an *action*, or *participative*, paradigm). In terms of the prevalent 'hard'–'soft' typology of 'systems' paradigms (e.g. Flood and Jackson 1991), the behavioural paradigm marked a start on the path of change from the traditional '*hard*' systems research and intervention paradigm, based on the objective knowledge of researchers 'outside' the system, to a '*soft*' paradigm featuring creation of circumstances in which farmer subjects discover new technical possibilities, experiment with change in their own systems, and construct new relevant knowledge from the 'inside'.

In what van Eijk cast as 'a gradual shift in paradigms', researchers came to recognise that

> '. . . only farmers can bring realistic "holism" to a research project . . . "Technology" is only part of the story. Important political, social, and the religious concerns affect

> farmers, who must weight technologies within a broader framework of "life"' (Van Eijk 2000, p. 324).

This change in thinking marks a shift to 'systemic thinking', or 'soft systems thinking':

> 'Soft systems thinking is concerned with situations as they are defined through action concepts. [ ] People have intentions that lie behind each action that they perform. Neither observation nor theory provides sufficient understanding to be sure of those intentions, that is, what is happening. [ ] It is necessary to progress beyond observation and theory to come up with an 'authentic' explanation about what is going on in the minds of involved people and hence meaningful action that might be taken. [ ]
> . . .to achieve a meaningful understanding of any situation, it is necessary both to study the cultural aspects of the context as well as the interpretations and perceptions that people form within the cultural context. . . .*'authentic' understanding of any action context requires participation of . . . all people involved in taking action*' (Flood 2001, pp. 137, 138; emphasis and interjections added).

The paradigm shift in this scion of FM centres on achieving the long-sought goal of relevance to practice, not by an adequately holistic treatment of the system by the 'outsider', but by inclusion, in the processes of system diagnosis and evaluation of change or proposed change, of the farmer with a systemic perspective from the 'inside'. This requires *profound* farmer participation, and the term 'participatory' is far from an adequate descriptor of the phenomenon. Ambiguity results from the fact that the field of FSR has differentiated into a *family* of participatory approaches to on-farm technical research that are distinguished mainly by the way power and responsibility are shared between farmers and scientists in various arrangements. Participation in FSR most often is either *contractual*, *consultative*, *collaborative*, or *collegial*, and types may vary among research activities (Okali *et al*. 1994, p. 96).

The prevalence of the concept of 'participation' in FSR as farmers 'becoming researchers', overlooks a complementary concept of 'participation' with demonstrated efficacy in achieving greater relevance of research to practice. The reciprocal notion of the researcher 'participating' in the farm management *practice* seems especially germane to possible paradigm change in FM research and intervention. As Checkland (1981) points out, in the context of action research, there are great benefits from such researcher participation:

> 'In action research the roles 'researcher' and 'subject' are obviously not fixed: the roles of the subject and the practitioner are sometimes switched: the subject becomes researchers . . . and researchers become men of action' (Checkland 1981, p. 152).

In the histories of other fields of management science, crises of relevance of a 'hard', science-based, rational intervention paradigm have been followed by the emergence of a 'soft' paradigm that recognises the human nature of management and the requirement of participative engagement for effective intervention in practice (Rosenhead 1989). This pattern, conspicuous in advanced stages of FSR, is conspicuous by its absence in the history of FM. An interesting question is whether FSR *was* FM's paradigm reform, or is it yet to take place.

Making sense of the successful Farm Management intervention approach of Jack Makeham

In their discussions of the failure of late era FM to be relevant to farm management, both Malcolm (1990) and Dillon (1979) singled out the exceptional case of Jack Makeham, who Dillon described as a 'successful academic and erstwhile farm management consultant'. Malcolm (1990, p. 34) highlights the side of Makeham's intervention approach that deals with farming as a human activity system. A brief consideration of Makeham's work combined with the above analysis of systems paradigms leads us to a proposal for future research:

> 'Makeham had described working in farm management as being a 'professional goal adjuster'. This involved working with the farm family towards the achievement of their short and long term goals, starting with the human element, given the technical, economic, financial, and institutional limitations of the situation' (Malcolm 1990, p. 34).

Makeham's own account of the nature of an engagement with a farmer is revealing:

> '. . .after a probing discussion, one or two patterns will emerge. The consultant's job then is to match the physical characteristics of the property (including its financial position) with the attitudes and intelligence of the owner. The farmer may state definite objectives but may not see that his physical and management resources don't match his desires. Or he may have 'vistas unperceived' and could be persuaded to lift his sights higher. [ ] The consultant has an inspirational role when the goals are limited compared with the present and potential resources' (Makeham 1965, p. 3).

The history of late era FM is the history of evolving approaches to applying economics to the task of rational factor allocations to farm production (Malcolm 1990; McCown *et al*. 2006). But Makeham's emphasis on farmer goal adjustment is something very different. In Part 1 (McCown *et al*. 2006), we called attention to the insight of Schultz (1939) of the 2 cognitive components of farm management, 'planning' and 'expectation formulation'. The latter was, perversely, both the more important and the one that FM was least-equipped to assist:

> 'We know that the prices and outputs which farmers expect are at best probable, very often nothing more than guesses, and sometimes even only hunches. Economic theory, however, is not able to give us much help. The price and output that is realized by the firm is usually something different from what was expected. The divergence between expectations and realization is a highly important matter from a practical point of view. [ ] Yet relatively little has been done in farm management to try to show how it might be possible to reduce this divergence between expectations and realizations, in spite of the fact that the gap between them is a positive measure of what is probably the most important source of inefficiency and waste in present day farming. Moreover, one may safely predict that no one would welcome assistance and guidance on how to lessen these divergences as much as the farmer, for he is quite aware that his most costly mistakes can usually be traced back to faulty expectations (Schultz 1939, pp. 585, 586).

Although we can find no reference by Makeham to Schultz, we feel that Makeham's intervention practice would have satisfied Schultz as being a rare example of FM intervention to aid farmers' formulation of expectations. Both the theoretician, Schultz, and the practitioner, Makeham, recognised the low potential of economic theory to meet farmers' management needs even when efforts were made to incorporate descriptions of farmers' expectations in the analysis. Inclusion of farmers' beliefs and preferences in the model provides for analysis that more realistically describes the farmers' planning outlook and the production of a more realistic production plan, but it does nothing to contribute to *more realistic expectations* by the farmer, which both Schultz and Makeham recognised as the key requirement for better farm management. Makeham and Malcolm (1981) summarised the debacle of the theoretical approach:

> 'There have been major difficulties in converting many of the insights of utility analysis into a form which is usable by either farmers or their advisers. It would seem to us that utility analysis was a well-bred horse, who performed encouragingly in the trials. Some of the boys backed it heavily for the big race. It led early, but fell in a hole halfway up the straight. The lads did their brass' (Makeham and Malcolm 1981, p. 176).

In addition to Makeham's attention to the personal side of farm management, Malcolm (1990, p. 34) noted that Makeham also placed 'great emphasis on the dynamic and risky nature of the management task', an aspect of management poorly served by economic theory. As Makeham put it in what Dillon (1979) referred to as 'by far the best text on farm business management yet produced':

'The two major challenges to today's farm manager:

(*a*) how to incorporate new technology profitably into his existing business organisation;
(*b*) how to be sufficiently flexible, mentally and financially, to adjust his resource management to meet both changed economic circumstances and widely varying climatic conditions' (Makeham 1971, p. 19).

In both these challenges, Makeham has identified the need for support in formulating expectations rather than in provision of rational plans. In addition to being subject to the uncertainties of volatile world markets, Australian dryland farm firms and households bear extraordinary climatic uncertainties. Makeham's approach appears to reflect the earlier observation by Schultz (1939) that

> '...the greater the uncertainty, the more nearly one must approach a state of planlessness, for uncertainty places a premium upon a short time span or flexibility in production' (Schultz 1939, p. 578).

In addition to Makeham's emphasis, noted by Malcolm (1990), on 'the social' and on 'uncertainty about the environment of farming', there is a third emphasis, i.e. the challenge to farm management of *change* in the environment (Makeham 1971; Makeham and Malcolm 1981, 1993). In introducing their book, 'The Farming Game Now', Makeham and Malcolm (1993) claim that ongoing change is implicit in modern farming and that much of what distinguishes 'good farm management' is ability to make appropriate and timely change. An implication of the insight of Schultz (1939) is that success in this aspect of management requires formulation of realistic subjective expectations of new, uncertain, possibilities.

Jack Makeham, in common with his FM colleagues, understood economic theory and was trained in the use of economic tools in FM. But he also had an understanding of the nature of the practice of managing a farm, which was uncommon among his academic colleagues. He certainly shared Dillon's later view that economic theory was inapplicable to farm management, and it seems likely that his enlightened experience of this in practice influenced Dillon's rethinking of theoretical FM.

Farm Management as systems research and intervention

We began this 2-part analysis of the FM experience by suggesting that FM originated as part of a change in industry and government that occurred around the turn of the 20th Century, which centred on making customary production and administrative practices more 'scientific'. Establishment in 1902 by the 'progressive' American government of the day of the Office of Farm Management flagged the beginning of a process intended to rationalise and professionalise the traditional practices of family farm management. This aligned with broader societal changes. However, by the 1960s and 1970s the social pendulum had swung back. Changes in community sentiment towards the professions and new government regulatory interventions were

> '. . .rooted in a deep questioning of the professionals' claim to extraordinary knowledge in matters of human importance. [ ] Finally, and most significantly, professionals themselves have shown signs recently of a loss of confidence in their claims to extraordinary knowledge' (Schon 1983, p. 5).

Professionals in FM were not exempt. Dillon (1979) made a convincing case that theoretical FM was actually *not* extraordinary knowledge about the management of farms as was widely assumed, but something quite different. He reflected that

> '. . .the discussion seems to have been conducted without drawing adequate distinction between farm management (i.e. the farmer's activity) and Farm Management (i.e. the professional activity)' (Dillon 1979, p. 11).

Somewhat more poetically, Malcolm (1990) later reinforced this point:

> '. . .over time, there emerged an increasingly commonly-held unease, and occasionally conviction, that these were trails which, if followed, soon led from the complex and difficult whole-farm pastures of plenty to simpler and easier analyses characterised by incomplete and inappropriate disciplinary balances and resulting in work which was not really about farm management' (Malcolm 1990, p. 49).

Having judged that FM had relinquished any claims to extraordinary knowledge about the management of farms, Malcolm envisioned an indirect role for FM in the future:

> 'That role is in the production of better agricultural economists and scientists through highlighting the limitations of their models of reality. So, academic work in farm management can contribute, even if almost accidentally at times, to the process of farm management' (Malcolm 1990, p. 50).

However, a concluding point in Malcolm's (1990) review points in another, more intriguing, direction:

> '. . .systems approaches to farm management problem-solving would *prima facie* appear to have the potential to be more relevant than more disciplinary-specialist inquiries to problem-solving in farm management' (Malcolm 1990, p. 47).

Although in 1990, he was no less critical of the systems approach than of the other 3 FM modalities he reviewed, by 2000, Malcolm was proposing his own pragmatic systems approach for FM. A future FM approach should not only be problem oriented rather than technique oriented, but multi-disciplinary and multi-methodological, and feature analyses for real farm situations. Without using the term, 'systems', he set out a systems manifesto:

> 'The farm management approach remains by definition the whole farm approach. If the management of farms is characterized as being a process involving human, technical, economic, financial, risk and institutional (beyond-the-farm-gate) elements, then processes of answering questions about farm management ought to have plenty of scope to incorporate aspects of all of these elements, in an appropriate balance, looked at from a small number of angles, for some imagined futures, as required. As Jack Makeham put it, "we're woods persons, not trees persons"' (Malcolm 2000, p. 20).

Although Malcolm (2000) presents a step forward, his methods do not capitalise on the advances in systems practices in recent years. In a recent attempt to foretell FM in the 21st Century, Mullen (2002) offers a diagnosis of the problem faced and a proposal:

> '. . .there is a need for increasingly sophisticated modelling of the impacts of complex technologies at the farm level. [ ] How information from this sophisticated modelling is made available to farmers and policymakers is another issue that is perhaps important enough to make the agenda for the 21st century. It is not clear to me how results from complex models are best explained to farmers and policymakers. It seems to me that farmers are unlikely to take on faith answers from black boxes nor will it be in their interest to fully understand a dynamic programming model of soil acidity, for example. Malcolm (2000) seemed to be

> arguing for a 'few figurings' of some sensible scenarios in a whole farm context. My guess is that farmers, well aware of their uncertain environment, are happy to make choices between technologies if the science sounds logical and if a 'few figurings' presented in transparent whole farm budgets but based on more complex models which suggests that a profit can be turned' (Mullen 2002, p. 13).

Taken together, the work of Malcolm (2000) and Mullen (2002) and the earlier simulation work reviewed above suggests the possibility that there may be an eclectic approach to systems simulation that bridges the gap between researchers and farm decision makers. A preliminary test of this hypothesis exists as a 10-year program of research aimed at finding 'if' and 'how' simulation models capable of dealing with many complex, dynamic and uncertain aspects of crop and cropland management could be used to provide significant value to farmers (Hochman *et al*. 2000; Carberry *et al*. 2002). During this period, on-farm collaboration of farmers, their advisers, and researchers created an eclectic approach that bridged some long-standing gaps between science and practice.

Hochman *et al*. (2000) reported that farmers came to value this FARMSCAPE (Farmers', Advisers', Researchers', Monitoring, Simulation, Communication, and Performance Evaluation) approach and that contributions to their management could be classed into 4 categories: benchmarking crop yields, production decision support, decision support for forward selling, and *ex ante* analysis of consequences of proposed management change. In all of these, input to farmers' expectation formulation is achieved through structuring of the farmer's uncertainty using simulation of the farmer's situation. Site-specific simulation is achieved using APSIM (McCown *et al*. 2002; Keating *et al*. 2003) and local historical daily rainfall records, current climate forecasts for the district coupled with historical years with the same forecast (analogue years), and measured soil resource states of the site in question.

Monitoring and simulation come together in communication events: meetings of researchers with local groups of farmers and advisers in farm homes and, increasingly, with the researcher attending, 'virtually', via Internet video conferencing (Hargreaves *et al*. 2004). Here, relevant issues—problems, possible solutions, apparent opportunities—are discussed, alternative management actions 'tried', and 'results' evaluated. A key evaluation tool is the gross margin spreadsheet, populated by simulator outputs and costs and prices nominated by the farmers. The relative frequencies of variable returns, made possible by dynamic simulation using historical weather records, provide an important enhancement to discussions around 'a few figurings'. In Australian dryland cropping, 'How often?' is implicit in 'What if?'.

Learning from a century of Farm Management

> '*In theory there is no difference between theory and practice. But in practice there is*.'
> *–Origin obscure and contested*

FM is one of a family of management sciences. It is concerned with better practical farm management through the application of theory/models to design of farming decisions and plans. Effect of a management science on practical management can be analysed in terms of the quality of its 'science' (research, theory) and the quality of its 'intervention' (implementation, application). Management sciences have a characteristic history of being found wanting in affecting practical management, and in these histories, failure is a failure in intervention, the notorious 'problem of implementation' in operations research/management science (McCown 2002*b*).

Late era FM conforms to these other histories in the failure of its economic theory of farm management to enable better farm management practice. Conceding failure must have been especially poignant for John Dillon in 1979. It had been only 30 years since the political victory of the theorists over the pragmatists in North America, which resulted in FM being 'reinvented' by agricultural economists, chief among them, Dillon's mentor, E. O. Heady. It had been only 15 years since Dillon became the foundation professor of the first university Department of Farm Management in Australia, and one committed to application of economic theory. Yet by 1979, he was convinced that what still seemed like sound theory was *inapplicable* to farm management practice.

This series of papers aims at explicating this surprising conclusion and pointing to a potential way forward. Part 1 (McCown *et al*. 2006) used a unique aspect of the history of this particular management science: the experience in an earlier era with importantly different science, different intervention, and greater effect on farm management practice. The especially reflective theorists, John Dillon (1965, p. 181) and Glenn Johnson (1963, p. 13), acknowledged that the earlier work had achieved a considerable degree of practical relevance and significance. But Johnson (1963) went on to point out a significant lapse in effectiveness of the early work. During the 1920s and 1930s, drastic changes in the farming environment took place and new problems arose. FM failed to lead in dealing with these new challenges, a failing that Johnson attributed to a loss of focus on farmers' problems. This led to the 'takeover' by agricultural economists in the 1940s and 1950s, which Johnson (1963) explains and justifies in terms of relative preparedness to address management problems.

Farms are purposive systems. In contrast to natural science, economics embraces human purpose. Economists claim that means–ends analysis through mathematical optimisation using problem owners' utility functions provides solutions to problems. The disturbing fact is that in 30 years of trying, such analyses had minimal effect on farmers' real problems. This has been repeatedly blamed on the failure of models to be sufficiently comprehensive. The models leave out key aspects of the farm and its management, thus rendering optimal designs based on 'partial' models, inapplicable to the more complex practice situations. Johnson (1963) recognised this problem and Malcolm (1990) restated it:

> 'Much academic work about farm management during the past 50 years lacked relevance because of a 'partial-farm management' orientation. This derives in part from a methodological focus which is too narrowly disciplinary and insufficiently dynamic, and also from the imperative of specialisation for progress to be made in particular disciplines' (Malcolm 1990, p. 24).

In terms of the aphorism quoted under the heading of this section, the only difference between theory and practice is that the representation of the practice by the theory is incomplete. The implication is that if only we could model the 'whole farm', the 'applicability' problem would disappear.

This problem of lack of holism seems to have led Dillon (1979) to recognise the qualitative difference between designed practice and 'lived' practice. He had given up on the idea of farmers finding theorists' solutions to problems being relevant to problems in practice. He had come to the realisation that the decades of problem-solving efforts had been conducted 'without drawing adequate distinction between farm management (i.e. the farmer's activity) and Farm Management (i.e. the professional activity)' (Dillon 1979, p. 12). He judged that the difference lay in the lack of 'holism' in the professional activity, but could see no methodology for rectifying the problem. However, perhaps the most important learning to be gained from FM is that relevance to practice may *not* depend on finding a methodology for achieving holistic *analysis*.

Karl Popper (1964) was critical of the concept of 'holism', especially the notion that a 'totality' can be the object of scientific study:

> 'The holists do not see . . . that all knowledge, whether intuitive or discursive, must be of abstract aspects, and that we can never grasp 'the concrete structure of social reality itself'. Having overlooked this point, they insist that the specialist's study of 'petty details' must be complemented by an 'integrating' or 'synthetic' method which aims at reconstructing 'the whole process' . . . [ ] Not one example of a scientific description of the whole, concrete social situation is ever cited' (Popper 1964, pp. 78, 79).

Popper was, however, sympathetic to an alternative notion of holism, one in which selective observation might reveal an abstract concept for organising inquiry. This concept of a *unifying theme* that gives meaning to a complex reality was taken further by Lilienfield (1978):

> 'The world is seen as an unlimited complex of change and novelty, order and disorder. Out of this total flux we select certain contexts; these contexts serve as organizing gestalts or patterns that give meaning and scope to a vast array of details that, without the organizing pattern, would be meaningless or invisible. Thus, an organizing context creates a "theme" . . . It "fuses" into a unity items that in other contexts appear as discrete entities' (Lilienfield 1978, p. 9).

FM (the professional activity) can only be about the theme (e.g. a management problem or an opportunity) that is defined by the researcher. The farmer has a different, 'inside' perspective, and a different set of unifying themes. For relevance to be achieved, reconciliation of these unifying themes of insiders and outsiders needs to be achieved through mutual understanding of each other's views and negotiation of meanings. The interpretation by Taylor (1994) of the relationship between FM and agricultural economics can be seen in this light:

> 'Farm management was less theoretical than agricultural economics. [ ] While containing the agricultural economists' general categories, the farm management literature was addressed to farmers and their immediate problems. The distinctive factors of production were subordinated to the subjective unity of labour, management and capital in individual farmers. The task of agricultural economics was to deconstruct this unity to reveal the economic unity beneath its surface. The task of farm management was to use this reality to mediate the reconstitution of the unity for individual farmers on individual farms' (Taylor 1994, pp. 52, 53).

Although this seems descriptive of farm management *consulting*, it seems that an adequate consciousness of this reality concerning differences between unifying theory and the subjective unity that constitutes practical farm management was all too rare among researchers in the late era of FM.

The fact that this function for FM in 'bridging' between economic theory and farm management practice was so seldom realized, led to the next step in a logical progression of innovations in intervention methodology. In FSR, joint *participation* of farmers and scientists provides an interface where these different themes of complex farming reality can be shared and negotiated:

> '. . .farmer's perceptions of problems are confounded by *life*: labour peaks, gender specialisation and social obligations. Their perceptions of opportunities are confined by the scope of their world-view. Only an analytical framework that penetrates below the surface to the problems of the system they operate has the full potential to reach into their lives. The importance of an interface with both inside and an outside understanding (neither of course perfect) cannot be overemphasized' (Collinson and Lightfoot 2000, p. 400).

This revolutionary concept for scientific intervention is summarised nicely by Van Eijk (2000):

> 'Only by having seen the whole, can one ask the right questions about the parts. In multidisciplinary teams with various single-discipline trained specialists, or in interdisciplinary teams with generalists trained in several disciplines, the researchers look from the outside to a whole, in our case a farming system. Approaching matters from this direction leads to confusion because the whole can never be seen from the perspective of the disciplines. We must reverse the arrows, and look outward from the perspective of the whole at all available knowledge from the various disciplines. Only the persons who are directly involved in, and manage, the whole, may command the outward-looking prospective vital to their particular management needs. This puts the farm-household members centre stage, and underscores the importance of participatory approaches . . .' (Van Eijk 2000, p. 328).

The upshot of this recognition of the radical difference between practice and theory—the distinction between farm management (i.e. the farmer's activity) and Farm Management (i.e. the professional activity)—is that solutions generated by the so-called problem-solving approaches of interventionists with models, are *not* solutions to the problems faced by farmers, so they are 'inapplicable' to practice.

An alternative in FM to solving problems for farmers has always been *assistance to farmers in solving their own problems in their terms*. Both Johnson (1963) and Plant and Stone (1991) championed formal (rule-governed) problem solving for farmers, the former with theory, the latter with formal heuristics. But both conceded the pragmatic value of provision of simply facilitating the decision maker in getting information relevant to the situation:

> '. . .the early descriptive, non-theoretical work in farm management was relevant for the solution of practical problems. The philosophy of science which guided these people was [ ] essentially positivistic. Though *positivism avoids purpose and leads eventually to difficulty in defining and solving problems*, the charge of irrelevance could not be levelled validly at the early farm management workers. *The closeness of these workers to farmers and their problems insured that the positivistic work they did involved the determination of facts which were relevant to the solution of problems facing farmers*' (Johnson 1963, p. 13; original emphasis).
>
> 'Providing information doesn't solve problems, although it can make a problem's solution trivial' (Plant and Stone 1991, p. 11).

The key components here are selective description and a participatory approach that together reconciles the respective unifying themes used by the insiders and outsiders.

FARMSCAPE takes a further step and combines simulation of relevant farming events and actions with relevant system description within a participatory approach. Systems are monitored and simulated in the context of farmers learning and solving problems. The nature of its break with earlier use of simulation in FM is flagged by Anderson (1974) when he notes his omission of management 'gaming' using simulation models from his review:

> 'Gaming models frequently process many of the dynamic, stochastic and structural features of typical simulation model (and indeed have often been termed "simulations"). However, there is one additional and distinguishing feature, namely direct human interaction in running the model' (Anderson 1974, p. 8).

FARMSCAPE features what Anderson left out. Using the representation of Fig. 1, in this mode, instead of 'Decision models' and optimised plans, farmers join researchers in 'what if?' inquiry concerning management of the production system aided by a flexible simulator of the production system. By their participation, life-world themes such as felt problems, are represented interactively, and in the 'gaming' activities of dialogic systems analysis and synthesis, new expectations and new relevant possibilities are often constructed (Carberry *et al*. 2002; McCown 2005).

Congruent with this perspective is the proposal by Pannell *et al*. (2000) and Malcolm (2000) for use of spreadsheet budgets to conduct 'a few figurings'. Instead of intervention with formal problem-solving/planning techniques, professionals can be relevant to management practice by providing conceptually simple tools to support farmers' formulation of certain types of expectations and deliberations leading to decision and action. The FARMSCAPE experience confirms the feasibility of Mullen's (2002) ambitious idea of using powerful scientific models along with 'a few figurings' as one promising way forward for professional intervention in farm management. But this experience also confirms the value of using these tools in intervention processes that support managers' subjective processes of sense-making and expectation formulation.

John Dillon (1979, p. 12) declared that he had thrown his lot with the systems paradigm of FSR: 'at least until the next revolution occurs!'. Discounting his characteristic hyperbole, this use of a complex science-based simulator to enable the acquisition of virtual management experience (Bakken *et al*. 1994; McCown 2005) is a paradigm change in intervention that appears to warrant a few assessments by farm management economists and farming systems scientists.

References

Anderson JR (1968) A note on some difficulties in response analysis. *Australian Journal of Agricultural Economics* **12**, 46–53.

Anderson JR (1972) An overview of modelling in agricultural management. *Review of Marketing and Agricultural Economics* **40**, 111–122.

Anderson JR (1974) Simulation: methodology and application in agricultural economics. *Review of Marketing and Agricultural Economics* **42**, 33–55.

Anderson JR, Dent JB (1971) Agricultural systems analysis: retrospect and prospect. In 'Systems analysis in agricultural management'. (Eds JB Dent, JR Anderson) pp. 383–388. (John Wiley & Sons: Sydney)

Anderson JR, Hardaker JB (1972) An appreciation of decision analysis in management. *Review of Marketing and Agricultural Economics* **40**, 171–184.

Austin EJ, Willock J, Deary IJ, Gibson GJ, Dent JB, Edwards-Jones G, Morgan O, Grieve R, Sutherland A (1998*a*) Empirical models of farmer behaviour using psychologic, social and economic variables. Part I: Linear modelling. *Agricultural Systems* **58**, 203–222. doi: 10.1016/S0308-521X(98)00066-3

Austin EJ, Willock J, Deary IJ, Gibson GJ, Dent JB, Edwards-Jones G, Morgan O, Grieve R, Sutherland A (1998*b*) Empirical models of farmer behaviour using psychologic, social and economic variables. Part II: Non-linear and expert modelling. *Agricultural Systems* **58**, 225–241. doi: 10.1016/S0308-521X(98)00067-5

Bakken B, Gould J, Kim D (1994) Experimentation in learning organizations: a management flight simulator approach. In 'Modeling for learning organizations'. (Eds JDW Morecroft, JD Sterman) pp. 243–266. (Productivity Press: Portland, OR)

Blackie M, Dent JB (1974) The concept and application of skeleton models in farm business analysis and planning. *Journal of Agricultural Economics* **5**, 165–173.

Byerlee D, Anderson JR (1969) Value of predictors of uncontrolled factors in response functions. *Australian Journal of Agricultural Economics* **13**, 118–127.

Bywater A (1990) Exploitation of the systems approach in technical design of agricultural enterprises. In 'Systems theory applied to agriculture and the food chain'. (Eds JGW Jones, PR Street) pp. 61–88. (Elsevier Applied Science: London)

Carberry P, Hochman Z, McCown R, Dalgliesh N, Foale M, *et al.* (2002) The FARMSCAPE approach to decision support: farmers', advisers', researchers' monitoring, simulation, communication, and performance evaluation. *Agricultural Systems* **74**, 141–178. doi: 10.1016/S0308-521X(02)00025-2

Charlton P, Street P (1975) The practical application of bio-economic models. In 'Study of agricultural systems'. (Ed. GE Dalton) pp. 235–265. (Applied Science Publications: London)

Checkland P (1981) 'Systems thinking, systems practice.' (John Wiley & Sons: Chichester, UK)

CIMMYT (1980) 'Planning technologies appropriate to farmers. Concepts and Procedures.' pp. 1–71. (Economics Program, International Maize and Wheat Improvement Centre: Mexico)

Collinson M (1982) Farming systems research in eastern Africa: the experience of CIMMYT and some national agricultural research services. MSU International Development Paper No. 3, Department of Agricultural Economics, Michigan State University.

Collinson M (2000) 'A history of farming systems research.' (FAO and CABI Publishing: Wallingford, UK)

Collinson M, Lightfoot C (2000) The future of Farming Systems Research. In 'A history of farming systems research'. (Ed. M Collinson) pp. 391–419. (CABI Publishing: Wallingford, UK)

Dent JB (1975) The application of systems theory in agriculture. In 'Study of agricultural systems'. (Ed. GE Dalton) (Applied Science Publications: London)

Dent JB (1990) Optimising the mixture of enterprises in a farming system. In 'Systems theory applied to agriculture and the food chain'. (Eds JGW Jones, PR Street) pp. 113–130. (Elsevier Applied Science: London)

Dent JB, Anderson JR (1971) 'Systems analysis in agricultural management.' (John Wiley & Sons: Sydney)

Dent JB, Blackie M (1979) 'Systems simulation in agriculture.' (Applied Science Publishers Ltd: London)

Dent J, Thornton P (1988) The role of biological simulation models in farming systems research. *Agricultural Administration and Extension* **29**, 111–122. doi: 10.1016/0269-7475(88)90010-4

Dillon JL (1965) Farm Management in Australia as an academic discipline. *Review of Marketing and Agricultural Economics* **33**, 175–189.

Dillon JL (1979) An evaluation of the state of affairs in farm management. *South African Journal of Agricultural Economics* **1**, 7–13.

Doyle C (1990) Application of systems theory to farm planning and control: modelling resource allocation. In 'Systems theory applied to agriculture and the food chain'. (Eds JGW Jones, PR Street) pp. 89–112. (Elsevier Applied Science: London)

Flood R (2001) The relationship of 'systems thinking' to action research. In 'Handbook of action research'. (Eds P Reason, H Bradbury) pp. 133–144. (Sage Publications: London)

Flood R, Jackson M (1991) 'Critical systems thinking.' (John Wiley and Sons: Chichester, UK)

Hargreaves DMG, Kethers S, Brereton M, McCown RL, Hochman Z, Carberry P, Antoniades M (2004) FARMSCAPE Online: participatory design of Internet meetings with farmers. In 'Proceedings of the Participatory Design Conference 2004 (PDC2004)'. Toronto, Canada. (CPSR (Computer Professionals for Social Responsibility), University of Toronto: Toronto, Canada)

Hochman Z, Coutts J, Carberry PS, McCown RL (2000) The FARMSCAPE experience: simulations aid participative learning in risky farming systems in Australia. In 'Cow up a tree: learning and knowing processes for change in agriculture. Case studies from industrialised countries'. (Eds M Cerf, D Gibbon, B Hubert, R Ison, J Jiggins, MS Paine, J Proost, N Roling) pp. 175–188. (INRA Editions: Versailles Cedex, France)

Johnson G (1963) Stress on production economics. *Australian Journal of Agricultural Economics* **7**, 12–26.

Jones J, Street P (1990) 'Systems theory applied to agriculture and the food chain.' (Elsevier Applied Science: London)

Keating BA, Carberry PS, Hammer GL, Probert ME, Robertson MJ, *et al.* (2003) An overview of APSIM, a model designed for farming systems simulation. *European Journal of Agronomy* **18**, 267–288. doi: 10.1016/S1161-0301(02)00108-9

Lilienfield R (1978) 'The rise of systems theory: an ideological analysis.' (Wiley: New York)

Makeham J (1965) Farmers' goals. *Farm Management* **1**, 3–4.

Makeham J (1971) 'Farm management economics.' (Gill Publications: Armidale, NSW)

Makeham J, Malcolm LR (1981) 'The farming game.' (Gill Publications: Armidale, NSW)

Makeham J, Malcolm LR (1993) 'The farming game now.' (Cambridge University Press: Cambridge, UK)

Malcolm LR (1990) Fifty years of farm management in Australia: survey and review. *Review of Marketing and Agricultural Economics* **58**, 24–55.

Malcolm L (2000) Farm management economic analysis: a few disciplines, a few perspectives, a few figurings, a few futures. Paper presented at the 44th Annual Conference of the Australian Agricultural and Resource Economics Society, University of Sydney, 23–25 Jan. 2000.

McCown RL (2001) Learning to bridge the gap between scientific decision support and the practice of farming: evolution in paradigms of model-based research and intervention from design to dialogue. *Australian Journal of Agricultural Research* **52**, 549–571. doi: 10.1071/AR00119

McCown RL (2002*a*) Locating agricultural Decision Support Systems in the problematic history and socio-technical complexity of 'models for management'. *Agricultural Systems* **74**, 11–25. doi: 10.1016/S0308-521X(02)00020-3

McCown RL (2002*b*) Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. *Agricultural Systems* **74**, 179–220. doi: 10.1016/S0308-521X(02)00026-4

McCown RL (2005) New thinking about farmer decision makers. In 'The farmer's decision: balancing economic successful agriculture production with environmental quality'. (Ed. JL Hatfield) pp. 11–44. (Soil and Water Conservation Society: Ankeny, IA)

McCown RL, Brennan LE, Parton KA (2006) Learning from the historical failure of farm management models to aid management practice. Part 1. The rise and demise of theoretical models of farm economics. *Australian Journal of Agricultural Research* **57**, 143–156. doi: 10.1016/S0308-521X(02)00020-3

McCown RL, Keating BA, Carberry PS, Hochman Z, Hargreaves D (2002) The co-evolution of the Agricultural Production Systems Simulator (APSIM) and its use in Australian dryland cropping research and farm management intervention. In 'Agricultural system models in field research and technology transfer'. (Eds R Ahuja, L Ma, TA Howell) pp. 149–175. (Lewis Publishers: Boca Raton, FL)

Mullen J (2002) Farm management in the 21st Century. *Agribusiness Review* **10**, Paper 5.

Norman D (2000) Farm management and the farming systems approach. In 'A history of farming systems research'. (Ed. M Collinson) pp. 293–299. (CABI Publishing: Wallingford, UK)

Norman D, Matlon P (2000) Agricultural system research and technical change. In 'Research on agricultural systems: accomplishments, perspectives, and issues'. (Eds JP Colin, E Crawford) pp. 17–48. (Nova Science Publishers: Huntington, NY)

Okali C, Sumberg J, Farrington J (1994) 'Farmer participatory research.' (Intermediate Technology Publications: London)

Pannell DJ, Malcolm L, Kingwell RS (2000) Are we risking too much? Perspectives on risk in farm modelling. *Agricultural Economics* **23**, 69–78.

Plant R, Stone N (1991) 'Knowledge-based systems in agriculture.' (McGraw Hill: New York)

Popper K (1964) 'The poverty of historicism.' (Harper Torch: New York)

Roling N (1988) 'Extension science: information systems in agricultural development.' (Cambridge University Press: Cambridge, UK)

Rosenhead J (1989) Introduction: old and new paradigms of analysis. In 'Rational analysis for a problematic world'. pp. 1–20. (John Wiley & Sons: Chichester, UK)

Schon D (1983) 'The reflective practitioner: how professionals think in action.' (Basic Books: New York)

Schultz TW (1939) Theory of the firm and farm management research. *American Journal of Agricultural Economics* **21**, 570–586.

Schultz TW (1964) 'Transforming traditional agriculture.' (Yale University Press: New Haven, CT)

Simon HA (1966) The logic of heuristic decision making. In 'The logic of decision and action'. (Ed. N Rescher) (University of Pittsburgh Press: Pittsburgh, PA)

Sorensen JT, Kristensen ES (1992) Systemic modelling: A research methodology in livestock farming. In 'Global appraisal of livestock farming systems and study on their organisational levels: concept, methodology and results. Proceedings of a Symposium organised by the INRA-SAD and the DIRAD-IEMVT'. 7–10 July 1990, Toulouse, France. (Eds A Gibon, B Matheron) (Commission of the European Communities: Brussels, Belgium)

Taylor J (1994) 'Fashioning farmers: ideology, agricultural knowledge and the manitoba farm movement 1890–1925.' (Canadian Plains Research Centre, University of Regina: Saskatchewan, Canada)

Thornton P, Dent JB, Bacsi Z (1991) A framework for crop growth simulation model applications. *Agricultural Systems* **37**, 327–340. doi: 10.1016/0308-521X(91)90056-G

Thornton P, McGregor M (1988) The identification of optimum management regimes for agricultural crop enterprises. *Outlook on Agriculture* **17**, 158–162.

Van Eijk T (2000) Holism and FSR. In 'A history of farming systems research'. (Ed. M Collinson) pp. 323–334. (FAO and CABI Publishing: Wallingford, UK)

Willock J, Deary I, Edwards-Jones G, Gibson G, McGregor M, Sutherland A, Dent J, Morgan O, Grieve R (1999*b*) The role of attitudes and objectives in farmer decision-making: business and environmentally oriented behaviour in Scotland. *Journal of Agricultural Economics* **50**, 286–303.

Willock J, Deary I, McGregor M, Edwards-Jones G, Dent B, Grieve R, Gibson G, Austin E (1999*a*) Farmers' attitudes, objectives, behaviours, and personality traits: the Edinburgh study of decision making on farms. *Journal of Vocational Behaviour* **54**, 5–36. doi: 10.1006/jvbe.1998.1642

Manuscript received 18 February 2005, accepted 7 September 2005