

A new role for hard science in soft Farming Systems Research: Learnings from ten years of facilitating farmers' experimenting using a cropping systems simulator.

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Abstract

Farming Systems Research helps bridge the gap between scientific knowledge about farming and practical knowledge about farming. FSR has provided a role for agricultural research other than that of using science to designing 'best practice' for farmers to adopt and apply. In FSR, instead of products of research being taken to the farm, research itself becomes an on-farm tool for reducing management uncertainties and discovering new opportunities. But while greatly increasing relevance of research to farming, practical on-farm experimentation has serious limitations, especially in climates where findings from a necessarily short study period poorly represents the expected future. This paper describes a ten year experience of working with farmers and their advisers to invent a way to use a complex, science-intensive cropping systems simulator to test new ideas as 'virtual experiments,' and, most importantly, to do so in a way that is meaningful and valuable to participating farmers. Crucial to this outcome has been a 'soft' intervention through the creation of mutual understanding between scientists and farmers, central to which is recognition of the importance of farmers' agency, policies, and subjective processes. Of equal importance has been the appreciation and validation by farmers and advisers of the 'hard' science representation of their production system. We conclude that significant value to farmers, advisers, and researchers can be added to FSR on-farm experimentation by the complementary conduct of virtual participatory experiments on virtual paddocks made to represent participating farmers' specific real paddocks and using their actual weather data for all years of record.

Introduction

Job satisfaction for many agricultural scientists is diminished by disappointment that more of what can be readily learned in research is not of greater value to farmers, and conversely, what perplexes farmers' management is often so awkward to research. Some give up trying to be useful to farmers. A few have given up on the science. Late in his career, John Dillon, Australia's first Professor of Farm Management, concluded that the economic theory of farm management was 'logically attractive but largely inapplicable' to the management of farms. He attributed the failure of the formal rigour of Farm Management economics to inherent realities of farming: farm systems are too complex, uncertain, unstable, and unique, and farmers have conflicting values and aims (Dillon 1979). His personal response to this dilemma was to involve himself for the remainder of his career in the, then, young field of Farming Systems Research (FSR).

Whereas Dillon's dilemma was quite personal and low key, a few years later Donald Schon's book, 'The Reflective Practitioner,' revealed a much wider phenomenon that encompassed Dillon's experience. Schon (1983) described the general crisis of the professions which began in the 1960s, and especially, the dilemma for many professionals.

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 and where situations are confusing "messes" incapable of technical solution. The difficulty is that the problems of the high ground, however great their technical 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 practitioners 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 rigour? (Schon 1983, p42).

One of the most remarkable features of the FSR enterprise was the leadership provided by a number of young agricultural economists who, like John Dillon, had been trained in a theoretically rigorous approach to Farm Management but who set out into the 'swamps' to find a way to assist farmers in adaptive change to their practice. One of these young Turks, David Norman, recently reflected on the experience.

Although researchers interacted frequently with farmers when farm management studies were being directed toward issues of technical change, the interactions were often *extractive* in nature, with researchers studying the farmer and his/her environment as objects, rather than involving farmers as actors in the process. [] Frustration with the lack of success led to the realization by many researchers that the conventional research paradigm needed to be modified drastically and replaced by one that would involve farmers as actors from the beginning of the technology design process... [] This paradigm shift provided the basis for evolution of a new approach, which involved moving from a "top-down" ("supply-driven") approach *to* farmers, to one characterized as being "bottom-up" ("demand-driven") *from* farmers (Norman and Matlon 2000, pp. 24, 25).

Our own experience that forms the basis of this paper began with our involvement in research with dryland farmers in Africa and the difficulties of researching crop and soil management on farms in a highly variable rainfall climate. On-farm experimentation provided a weak approach to key questions like, 'How much scarce family cash should be spent on nitrogen fertiliser when there is a high chance of crop failure, but when it is certain that if the season is good, opportunity for surplus will be foregone because of soil N deficiency?' We judged that on-farm experimentation could be strengthened by using simulation modeling to conduct 'virtual' experiments in years for which weather records existed (McCown et al. 2002a)—that, to paraphrase Kurt Lewin, nothing would be as *practical* in FSR in these circumstances as a good theoretical model. APSRU began research in the northern cropping region of Australia in 1992 with this outlook. But by this time, we had come to think that farmers should be involved in research on simulation in farm management. This paper discusses the evolution of our process for this unorthodox approach to FSR over the past decade.

The Research Process

The research team began with a relatively well-developed capability to simulate crop production in relation to weather and crop / cropland management activity for a given site. Early interactions with elite farmers and advisers in the region revealed deep skepticism that models could be anything other than 'toys for scientists.' An action research program was undertaken to answer two high-order questions: (1) Can farmers come to value simulation as a tool for managing climatic risk? and (2) if so, how can benefits be delivered effectively and sustainably?

In recognition of farmers' skepticism about the practical value of our simulation models, we began with a conventional FSR approach without models, engaging with farmers on management issues that were both perplexing to them and within our domain of research competence. With financial support from GRDC we negotiated studies with farmers in two groups in Central Queensland and one on the eastern Darling Downs concerning management of soil water and nitrogen and the economics of N fertilizer on dryland sorghum, cotton, and wheat crops (Cox 1993). The experimental units were strips in commercial fields. The researchers, firstly, provided a service of monitoring, to depth, the soil water and nitrogen supply as well as crop growth. They also facilitated discussions of the results with groups of involved farmers and advisers. At some point

the interesting question would arise in group discussion, 'how would the results differ if we had done this study last year?' This provided the opportunity to raise the possibility of conducting the experiment *virtually*, using the simulator, with last year's weather (Step *e* in Figure 1). But this came after simulating the *real* experiment just completed to establish the credibility of simulator to provide a valid virtual experiment (Step *d* in Figure 1). The approach proved to be effective in reducing skepticism and led to simulation-enabled virtual experiments becoming a valued way for groups and individual farmers and advisers to pursue answers to pressing management questions.

From the outset we hypothesised that (1) discovery of value of simulation by a farmer is most likely to take place in the context of a real problem in his/her paddock and (2) that such discovery is more likely to take place in farmer groups and where an expert is operating the computer and the simulator. Figure 1 summarises the approach that evolved from the early experiences described by Carberry et al. 2002 and which we named FARMSCAPE (Farmers, Advisers, & Researchers, Monitoring, Simulation, Communication, And Participatory Evaluation). The cycle of action is in synchrony with the seasonal cropping cycle, and embodies activities of team reflection and learning from experience, both overall and in each step.

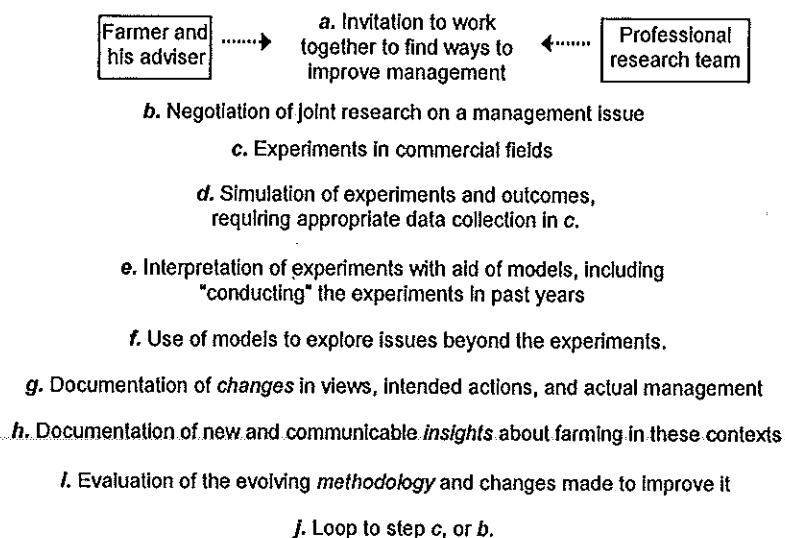


Figure 1. The iterative process for learning how to use simulation to provide value to farmers in their thinking and planning.

In this approach to FSR there are two foci for interactions between farmers, advisers, and researchers. The first is in the field and concerns the collecting of soil information that is outside farmers' normal practice (Dalglish and Foale this volume). Farmers have gained insights about the nature of their own soils, discovered management value for new below-ground information, and have been innovative in putting in place practical systems for monitoring that both helps them in their decision making and serves to specifying the simulator for their paddock(s).

The second interaction takes place inside where there are conditions conducive for discussions among farmers, advisers, and researchers, aided by representations of the field data and a flexible simulator that can mimic crop production and related management matters under specified relevant conditions. The remainder of this paper will focus on these interactions as participatory FSR. Evidence has been provided elsewhere that our foundational question, 'Can farmers value simulation as a tool for managing climatic risk?' has been answered in the affirmative (Carberry et

al. 2002; Hochman et al. 2000). The emphasis here will be on our efforts to understand this outcome and what it might mean for FSR in the future.

The Intervention Process

That a cropping systems simulator could serve as the engine for interactions that are valued by farmers tends to be surprising both to professional facilitators of farmer groups and to those who make simulation models. There seems to be little precedent for it in the history of agricultural modelling. Earlier attempts at using models in farm management took quite different approaches. In the 1970s and '80s as part of the Farm Management enterprise, simulation modelling introduced greater realism to economic analysis by adding time dependence and frequency of occurrence to otherwise static optimising models meant to aid farmers' planning of resource allocation. But it didn't alter the fate of this scientifically normative approach to intervention whose demise Dillon had flagged earlier, with or without 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).

In a second attempt, simulation models were used in Decision Support System (DSS) development in the 1980s and '90s. The DSS idea had originated (outside of agriculture) as a *solution* to the problem of rejection by managers of recommendations based on simulation and was based on the (vain) hope that by providing software that managers themselves could use, formal models would become more integral to practical management (McCown 2002b). But this expectation overlooks the normative nature of most DSS software, with its implicit, programmed "if [condition]..., then do..." approach to action. Such an approach to management intervention has been rejected by the manager who has a high degree of discretion and agency (is pretty much his/her 'own boss'), e.g. senior managers in industry and family farmers (McCown 2002c).

The simulation models used in FARMSCAPE, while much improved and imbedded in a new generation of software and computers, are of the same nature as those used in previous efforts. The crucial change has been in the way the tool is used in the intervention.

There are two critical innovations. The first is that in FARMSCAPE, intervention consists of offering the simulator as a means for farmers and advisers to try out ideas—to experiment. This type of inquiry tends to begin with a "what if" question and leads to rich discussion around what to try the credibility of the results, and what might this mean for management. "What if I did...?" is diagnostic of a soft approach to intervention that begins with a farmer's articulated idea for solving a felt problem. This contrasts with 'hard' intervention in which professional problem solvers produce scientific recommendations as to what the farmer *should* do to solve his/her problem.

The second innovation in FARMSCAPE intervention has been the specifying of the simulator for real paddocks and actual circumstances that constitute the setting for the farmer's problem. The importance of this was recognised from the early days of simulation models in Farm Management. But the cost of such customisation was considered to be cost prohibitive (Anderson and Dent 1971), so it was rationalised that simulating notional situations rather than actual situations was adequate for the purpose of choosing among alternative actions. The critical oversight was the importance of local specification to making the simulation subjectively meaningful to the farmer.

The FARMSCAPE research (Figure 1) has produced two rather distinct intervention processes (McCown 2002c). The first, as reported by Carberry et al. (2002), came about through the creation of a market for simulation-aided service to farmers, a positive response by the consulting industry, and training and accreditation of consultants in using this approach. In the 'fee for service' modality of interaction between a professional-with-simulator and a farmer, a 'hard' approach may often be appropriate. In these social circumstances, repetition of earlier failure to be relevant to

farmers may be avoided by the new feasibility to specify the simulator for specific paddocks and soil conditions using data collected by the consultant. This may enhance consulting effectiveness, but this is not FSR. The focus in the remainder of this paper is on the second product – which has as its core ‘hard’ scientific models, but uses a ‘soft’ intervention process in sympathy with farmers’ agency, policy and subjective decision and learning processes to facilitate farmers’ “experimenting” with their management.

Conditions important for farmer participation in *virtual* on-farm experiments

The application of science to agriculture has been greatly enhanced by on-farm participatory research, even though research stations remain the venue of preference for certain types of research of value to farmers. But where seasonal variability in rainfall is very high, a competent and flexible cropping systems simulator enables a complementary mode of research with comparative advantage in making agricultural science useful in the farming practice situation. Of course, it has its own limitations, the most obvious being that the experiments are *virtual* rather than real. It is not surprising that farmers tend to be sceptical about what could be esoteric science-based, high-tech, distractions. We tend to share the view of the eminent management scientist, Peter Keen, that, “Until relevance is established, rigor is irrelevant” (Keen 1991, p27). But when farmers have revealed that an intervention has been relevant and significant, we have been students of the influences and processes that bring about such outcomes.

We have seen no indication that farmers are in the market for simulators of farming of the computer game genre. Not surprisingly, farmers are very demanding of convincing evidence that simulations can be taken seriously as substitutes for comparable real world events. They typically require a high degree of realism in simulations of important things like grain yield, but they are *practical* in this need, rather than scientific. Both the stringency and the practicality of expectations are reflected in a farmer’s telephone call to put a researcher ‘on the spot’: “We’re about to harvest that wheat paddock we have been monitoring. What yield does APSIM say I am going to get?” A satisfactory outcome of this test typically provides more confidence in the simulator than a ‘tight’ regression of simulated yields on experimental yields. Similarly, there is a willingness to judge the goodness of a simulation pragmatically, relative to the farmer’s alternative means for anticipating outcomes, rather than absolute measured value.

Farmers’ efforts to validate the simulator for their use are not only empirical. There is a degree of structural validation taking place as well. A common type of question is “does APSIM consider effects of disease on yield?” The typical response to the answer that it does not, is characteristically contrasting to the response of critical scientist. Farmers are generally unconcerned by the fact that APSIM does not simulate disease effects, as long as they are aware of that fact and can then proceed to make appropriate mental adjustments. Their pragmatic view is that they normally have to rely on their judgement in anticipating the outcomes. They welcome the contribution of APSIM to structuring the complexity and tend not to be critical of less-than-comprehensive treatment, as long as this ‘partialness’ is transparent.

In addition to requiring satisfaction of *credibility* criteria, the likelihood of a farmer choosing to engage in WifADs depends on the farmer’s discovery that this approach can satisfy practical management needs. This is what distinguishes it from a toy---possibly even an accurate toy. Over a number of years of engaging many farmers using the simulator on questions raised by them, the cases can be usefully classed into four categories: benchmarking, production decision support, marketing decision support, and analysis of consequences of system change. Hochman et al. (2000) and Carberry et al (2002) provide examples of these. The important point to be made here is that these are areas of farm management in which practice is made difficult and hazardous by uncertainties in the environment and/or in the tasks, especially if the task is an innovative one, e.g. undertaking a new dryland cotton enterprise. Probabilistic outcomes of virtual experiments often

provide the best guides for action to farmers who must commit to act in spite of very uncertain expectations about in-crop climate.

In addition to the empirical and structural validation of a simulator performance, there is a type of validation that concerns the interpersonal relationships between the farmer and the scientist. While somewhat less tangible than the other two, we believe it is no less important. We choose to articulate this as the role of *mutual understanding* (Churchman and Schainblatt 1964; McCown 2002c). In brief, we believe this entails, most fundamentally, the scientists appreciating the essential nature of being a family farmer with agency, policy and informed process for translating policy to actions. This contrasts with the view of a farmer primarily as a user of transferred scientific information. When a satisfactory state of mutual understanding exists, farmers appreciate that scientists are not regulators, advocates, or touts, but rather are inquirers and facilitators, committed to finding ways to use their science to create value for farmers' in their execution of their policy and process.

A constraint to farmers experimenting in a virtual paddock is that the virtual paddock is necessarily strange and inhospitable in important respects. A farmer in the real world of farming practice experiences the behaviour of this world through sensory perceptions and responds adaptively. Effective action in this world of farming practice is generally not dependent on first knowing its *deep structure*. But to provide a simulated, virtual world of farming practice, simulation of the behaviour of the world depends on mathematical models of deep structure. The interface between the farmer and this virtual world is necessarily less familiar and engaging than in the case of the real world. Deprived of 'kick the dirt' sense of presence, the manager of the virtual system must learn to communicate about familiar things in somewhat new ways. This involves a degree of cognitive shift from action-centred perceptual processing to a computer mediated, theoretical understanding (Zuboff 1984). The fact that the structural complexity of a cropping systems simulator such as APSIM is such that scientist users have only partial understanding helps put the required shift by farmers in perspective. But while the required adjustment may be something of a deterrent, sometimes this 'seeing things differently' has practical payoffs.

APSIM simulates variation in soil water using a water balance sheet. The capacity of the soil for storing water can be determined quite easily, and agronomists (as opposed to soil physicists) find it simple and functional to express the existing store of water to sustain crop growth as a decimal fraction of this capacity. The legacy of our early uses of a metaphor of the soil profile to the depth of rooting as a 'bucket' can be heard in 'farmer talk' about soil in the region: "How big is the bucket in that soil?" So, in addition to being an adequate scientific framework for dealing with soil water, many farmers have decided that the water balance concept provides a superior practical device for thinking and talking about this primary environmental factor.

Intervention process in relation to interventionists' view of 'farmer' and 'management'

The story of FSR is a story of evolution in processes of intervention in farming practice, in which *research* becomes the *intervention*. Any intervention paradigm is closely coupled to a particular stereotype of the farmer and the 'process' of management. Having progressed, using action research, in inventing a process with a degree of effectiveness for engaging farmers in inquiry regarding their management, we are working hard to understand how to interpret this in terms of what it is to be a successful farmer today. In doing this we have found it helpful to reflect on previous intervention paradigms, aided by variations on the representation of Sorensen and Kristensen (1991) that realistically recognises that a farm comprises a system of human management as well as a production system (Figures 2-4).

The only intervention paradigm prior to the emergence of FSR, and arguably still the dominant paradigm, is that of 'applied research and technology transfer' (Figure 2). Here research produces

guides for best technical practice from research on farming systems that do not include the farmer. In this 'hard' paradigm it is difficult to represent the management system as other than a 'black box.' In this representation, 'management' or 'social' factors could relate to production via numerical coefficients that reflect degree of deterministic connection to production processes. Little wonder that this paradigm has been plagued by a problem of farmer indifference, with the human component of farms, a problem variously referred to as one of "non-adoption," "inapplicability," and difficulty in "implementation."

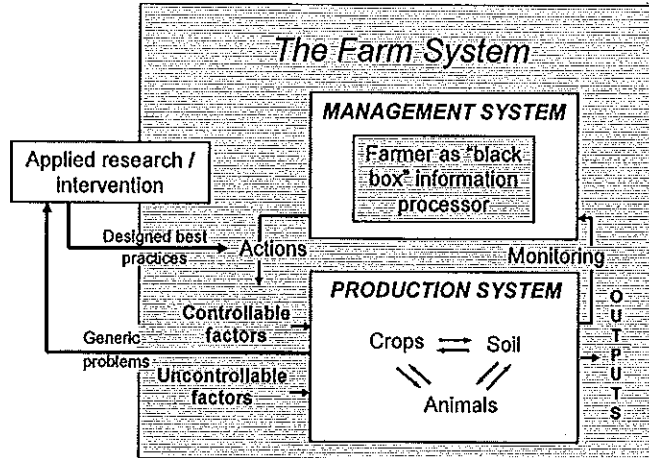


Figure 2. The traditional intervention paradigm of applied research targeting actions.

Farming Systems Research tackled the problem of ineffective intervention and transfer by taking the research to the farmer. In this paradigm (Figure 3) the farmer is viewed as a representative of a target category of farmers whose involvement in problem formulation in evaluation of research outputs is seen to be crucial to improved intervention as reflected in adoption of the new technology

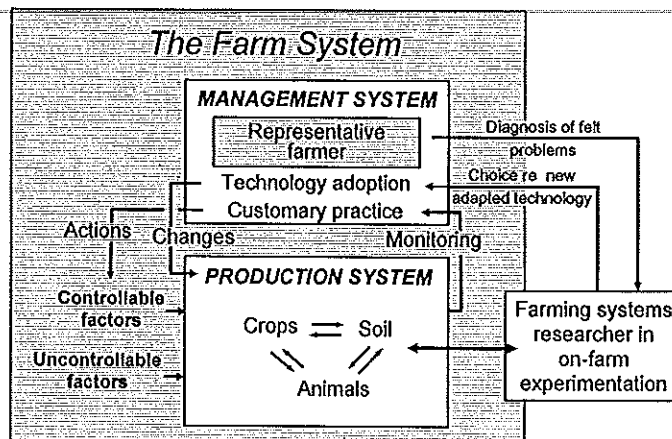


Figure 3. The early FSR intervention paradigm of on-farm research sensitive to 'the market' for innovations

In the last 15 years there has been a paradigm change that can be characterised as seeing the farmer as a person rather than as a representative of a type of farmer. The implications of this paradigm change are important in two complementary ways. Many FSR workers, especially in circumstances

of serious political inequity, emphasise the importance of the freeing of the individual farmer from unfair political forces that prevent him/her from reaching his/her potential. But other workers, and in places like Australia, see the importance of this paradigm change primarily in offering greater effectiveness in providing research benefits to farmers—in increasing intervention effectiveness through greater relevance and significance of research efforts.

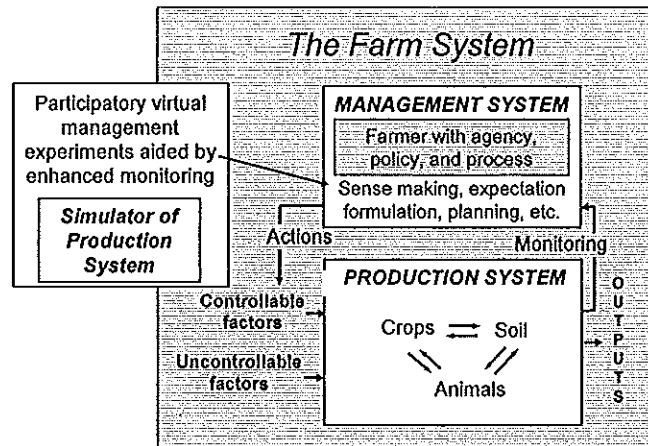


Figure 4. A paradigm for intervention that focuses on support for agents' processes and uses a FARMSCAPE approach to relieve limitations of on-farm research.

In keeping with the aim of farmer empowerment, the dominant trend in research process in this paradigm of FSR is increased control of research by farmers. The governing values in this change tend to lead to focus on ways to minimise dependence of farmers on scientists. The alternative view, which we hold (in the Australian context), puts emphasis of synergies in co-creation of innovations that benefits farmers in their learning and management of production activities.

Figure 4 represents a variation of this paradigm in regard to the FARMSCAPE approach to FSR. Of central importance here is the farmer's experience in implementing his/her policy. There is recognition of and respect for the human processes of making sense of own and others experiences and coping with multiple uncertainties in acting. The key research question concerns how rigorous scientific models of production systems can be sufficiently meaningful to serve as virtual worlds in which farmers can experiment and acquire experience useful in management. The benefits of such research are seen in both intentions and practices of farmers and in the new insights and knowledge gained by scientists, captured chiefly through the improvements to our scientific models (Robertson et al., 2000; Carberry et al., 2002; Foale et al., 2003).

This paper has described the process and the current state of our efforts to invent and institutionalise a means for achieving a meaningful role for our 'hard systems' models. This would seem to qualify as participatory FSR. But it is significant that it also qualifies as new paradigm marketing where the focus is on the co-creation of value with end users (Normann and Ramirez 1994) and as new paradigm technology design in which technology is viewed as both the result of 'social construction' and as active in social shaping (Glock 2003). Although there is ample evidence that farmers value what has been co-created, much remains to be done before it is clear 'if' and 'how' a sustainable structure for providing this new simulation-based service can be put in place.

Conclusion

Scientific intervention in social practice provides either *proxy* for practitioners or *tools* for practitioners to use (Collins and Kusch 1998, p119). Agricultural research that uses science to

design 'best practice' provides proxies for farmers' policies and processes. In response to the failure of farmers to embrace proxies for their management, FSR has tailored scientific research to the farm situation and facilitated evolution of tools for farmers' experiments. But tools for simplified/pragmatic on-farm experiments do not exhaust the non-proxy possibilities for science to serve farmers policies and processes. The FARMSCAPE experience provides another FSR possibility with apparent promise, especially in unstable agricultural climates such as occur in Australia, where uncertainty about the weather so seriously impairs farmers' sensemaking and planning.

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