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Theory & Practice in FSRE: Consideration of the Role of Modelling [1]

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ABSTRACT

This paper has three major sections: the first attempts to analyze the process of farming systems research-extension (FSRE); the second represents an enquiry into the nature and need for models in FSRE; the third is a philosophical discussion about concepts and paradigms required for further modelling as an essential component for more efficiency in FSRE.

In the first and second parts, emphasis is placed on FSRE as a holistic concept that incorporates some modelling component as a vital part of the process. The nature of such models is discussed. The second part of the paper progresses from the point of view that any discipline or branch of study that does not develop its basic paradigms will fail to progress and will be replaced by more robust approaches. Research into FSRE itself has been limited and consideration is given to the role modelling could play in research activity into the ideas and concepts of FSRE.

THE FSRE ACTIVITY SEQUENCE

Figure 1 attempts to capture the basic steps in the process of farming systems research-extension (FSRE). The most noticeable activities within FSRE are focused on the applied/adaptive research step. Simplistically, this may be viewed as the development of appropriate technology followed by demonstration of this in farmers fields. The research carried out is guided by the perceived needs of farmers in the district or defined agro-ecological zone. So, zone definition, description of the farm system(s), and establishment of databases must be the first step in the whole process. From this first step to the prioritization of research represents an enormous logical leap. In Figure 1, this leap is shown as assisted by some form of modelling. This is universally the case, even if for the most part the modelling is implicit and non-formal.

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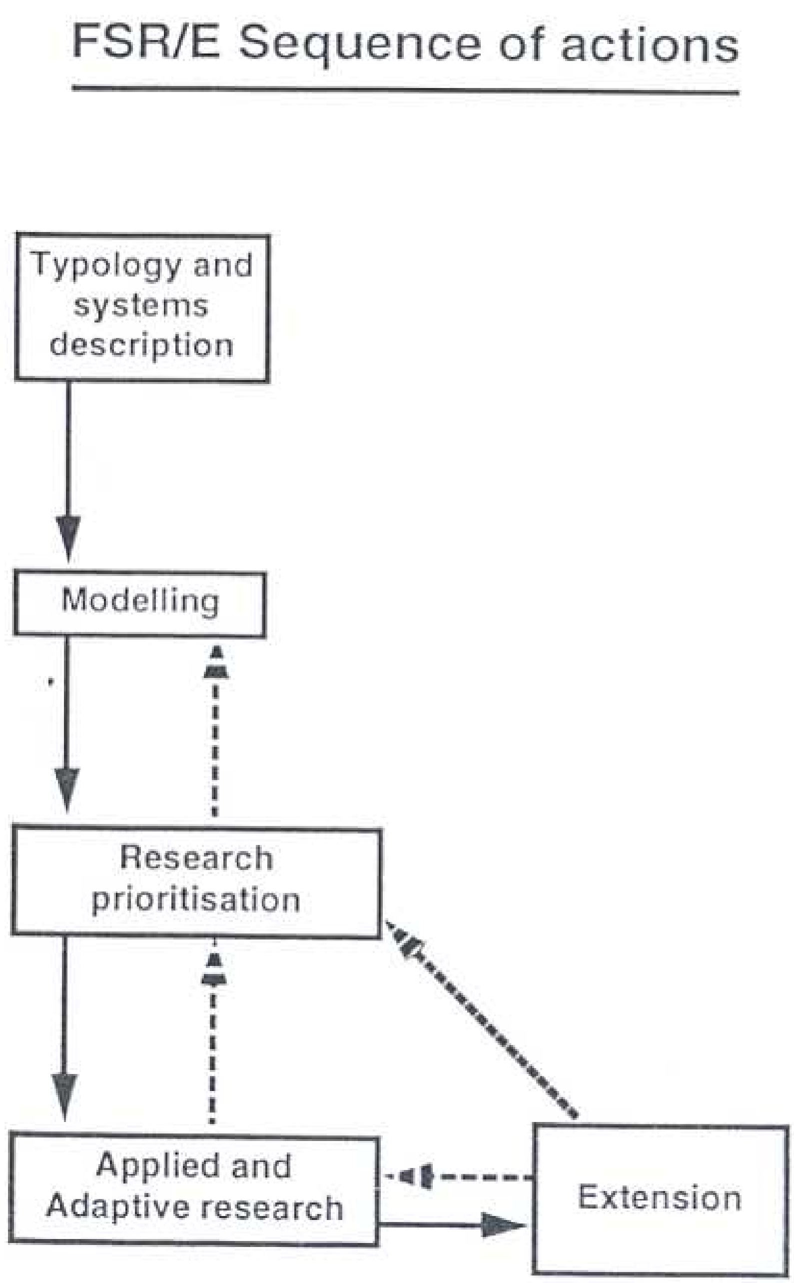
Figure 1



Adoption of technology that will permit improved farm systems in terms of level and reliability of output is usually seen as the overriding aim of FSRE. The technology is generated in the series of vertical steps in Figure 1 together with the indicated feedbacks. An important feedback in this respect is implied within the single block of the figure linking applied research with the adaptive research procedure. Technology development is portrayed as reliant on field experimental work.

This dependence on field trials to develop 'technology packages' has got to be a matter of concern. Particularly in locations characterized by climatic variability, the cost/effectiveness of such work must be questioned. Observed and significant differences between treatments may be relevant only for the year and specific conditions of the trial. Other circumstances may negate or reverse treatment priorities. Repetition over years only expands the cost without necessarily improving the information provided and results in unacceptable delays. Other areas of biological science have developed adjacent methodologies (Jones & Kiniry, 1986) in response to this situation. Computer models of crop and livestock enterprises are widely available and well tested and should by now be replacing some routine field experimentation (Dent & Edwards-Jones, 1991). Here is a first, simple, and relatively well proven opportunity to apply modelling methods with potential gain to conventional FSRE.

The process of FSRE is then essentially driven by technology. Farmers are included in the research process because there is little doubt that, otherwise, factors can be overlooked which can hamper the subsequent adoption of successfully tested recommendations.

Hence, the concept has grown of FSRE being concerned to improve the efficiency of farming systems *within the socio-economic constraints* on development. This concept must surely be questioned; socio-economic factors should not be viewed as constraints but specifically as *part of the system itself*. The soil type may be a constraint, as may the climate, but the social organization of the farm family within its community is as much part of the system as the organization of crop production. Because FSRE recognizes the farmer as the main client of research, it must address high priority problems for farmers; these, however, are not always related to existing and currently operated technology or even to under-performing farm systems. (Byerlee & Tripp, 1988; Farrington, 1988). Hence, in rural areas, the farm as such, and its associated technology, should not be the sole (or even the main) focus for development. This is a crucial element because it begins to generate doubts about the kind of research as well as the research resources committed to FSRE in the name of development.

An alternative definition for FSRE and one that specifically emphasizes people and the social framework in which they live and work, as distinct from technology, is offered by Brossier & Chia (1994). They see FSRE as oriented toward farmers, of course, but argue "that researchers are not external to the systems under study." This Action-Research defines farmers and local operators (researchers, extensionists, local business) as *part of the system*. This is a view that generally appears to be favored by exponents of the soft systems approach (Checkland 1993; McAdam, et al., 1994); it specifically incorporates an analysis of processes and structures needed to deliver enhanced institutional frameworks and improved social, economic, and technical processes.

This paradigm is quite different from technology oriented FSRE. It is not necessarily (or mainly) on-farm experimental (trial) based and it is designed to release discovered "bottle-necks" that may be related to institutional incapacity, poor information flow, structural deficiency (e.g., inappropriately defined property rights), cultural restrictions, or technical limitations. Research/investigation may then be prioritized as social, cultural, administrative, or technical problems within rural communities. From this realist perspective, FSRE is best seen as being activated when technology becomes an obvious restriction on the farming sub-system to the extent that it limits growth of the welfare of people in the defined community system.

MODEL TYPES IN FSRE

A crucial step that appears not to be formally addressed from the FSRE activity sequence is how (by what mechanism) perceived problems are identified, how they are prioritized, and what exactly is the 'research' process used to solve problems.

Figure 1 suggests that these processes are, in practice, achieved by a modelling activity. It is necessary now to clarify this by examining the model types that have been and may potentially be involved.

Implicit models

In FSRE practice such models are the norm and may perhaps better be described as 'mental' models. We all recognize such models that develop over time to become a mental framework that provides the structure for thinking about and defining a system. In an informal way the sub-systems, the driving variables, the outputs, and conditions (the 'environment') are assembled. Often such models are refined by discussions with colleagues and also with farmers and their families. Although informal, they can still be powerful constructs.

The problem with such models is that neither their structure nor the embedded interactions are stated or quantified. Neither can they be formally tested (validated). Furthermore, it is difficult to provide for sensitivity analysis, which is crucial for prioritization of research/investigation activity. Additionally, the system boundary definition is not specifically stated and this can cause fuzzy thinking in determining priorities of research. Most usually, the model relates to a perspective of a farm typical of the defined zone and the boundary is associated with the farming system.

Clearly, FSRE practitioners use their experience against their mental model to gauge priorities for the research phase. Their judgements, however, are less easy to assess (and to share with others) than when the model is explicit and more formal.

Computer Models

Many reported examples have exploited mathematical programming concepts to create suitable models at all levels of application. In Action Research, for example, linear programming models have been used to explore the response of a representative farm to potential new technology or management.

This process has been used to assist in formulating research needs by discussing output from the model with the actors involved. Farmers are, of course, part of this dialogue, but in addition the outputs from such models have been used in discussions between farmers and their wider community (e.g., market organizations). In reported examples (Brossier, Vissac, and Le Moigne, 1990) this has been seen as a useful device to ensure that farm technology, infrastructure, and socio-cultural elements are considered in harmony. Some authors have specifically outlined the mathematical modelling methodology which provides for the links between farming systems and the broader communal economy (see Dent and McGregor, 1993; Doppler, 1994).

Those models that have been developed have tended to include structural variables such as farm size and enterprise mix, whereas the social elements of the systems (usually households) have been assumed to be uniform and to act as rational financial maximizers (Wossink et al., 1992). Although possible within such models, it is not usual to illustrate the impact of trade-offs between the many and different objectives within farm households. Other mathematical programming structures (such as goal programming) have this capability and examples of their value have been provided by Romero & Rehman (1989). Such models are conceptually quite simple but are still normative in nature. Thus an objective may, for example, be stated that the typical farm household for a defined zone would not wish to take more than X units of seasonal credit into their farming system and then only if overall 'profit' was likely to be greater than Y units.

But the issues relating to credit use are much more complex than this and few farmers are interested solely or even mainly on achieving high levels of 'profit.' As a result, attempts to create models of *behavior* of the typical farm family are now beginning to emerge (e.g., Edwards-Jones et al, 1994). In such models, and staying with the same example, the level of credit uptake has been linked to the age of the head of the household, whether this is a male or a female, and the level of education achieved by this person. Availability of credit may be determined by the equity status of the household and the past record of credit use.

Behavioral models that may associate decision making with key characteristics of the farm household and of the community in which the members live and work, as well as to the prevailing infrastructural and institutional conditions, are in the early stages of development. Mostly, they incorporate experiential information, and examples to date are established within a rules-based framework.

The range of different models outlined in this section have different characteristics and it is important to select the model type to the circumstances of the FSRE program and the information available. Mathematical programming models largely require quantitative data input; behavioral models, on the other hand, are able to accommodate qualitative assessments and 'rules of thumb' as well as quantitative relationships. Behavioral model approaches may be said to be more closely akin to mental models but expressed within a more formal structure.

Soft Systems Models

Models developed under a soft-systems approach have characteristics that are similar to those described under Action-Research. Their main function is to create debate and discussion about an agreed problem area in development, by providing indicators that describe possible outcomes of alternative actions. Such models can be developed at a farming systems level but are much more likely at rural livelihood systems level. The soft systems methodology may be summarized as follows.

Soft Systems Steps:

1. Determine the problem situation.
2. Analyze the situation development of the 'rich picture.'
3. Create the conceptual model (ensure validity).
4. Generate feasible and desirable changes options for change by way of model.
5. Actors discuss resource and infrastructure limitations.
6. Implement changes.

The process is not as focused as FSRE because field-type research is not a target. Work is centered on debate by key actors associated with the system under study and the conceptual model is drawn-up by all actors as a mechanism for helping the debate. The conceptual model may involve quantitative elements but discussions are often based on qualitative assessments.

The model involved in this process often takes the form of a description of the system—a picture description shared mainly by the actors involved. Conflicting objectives among groups of actors is likely to be endemic, whether at farm household level or at community level, and where progress is related to relaxation of institutional or infrastructural constraints, moving forward may clearly be painfully slow. On the other hand, the model may identify simple constraints that, once released, may move the system 'up a full step' in meeting objectives.

Often answers will relate to lack of official commitment, institutional inadequacies, poor information flows, and poor participatory learning experiences. Experimentation and demonstration are not specifically brought into the cycle of events, but they are not excluded either. The process then is not related to the development of research priorities but to examination of the whole raft of conditions that restrict local people in attaining their (perhaps poorly inarticulated) targets.

A SYSTEMS APPROACH

To this point, discussion has been focused on the importance in development of defining appropriate systems and the role of modelling in the exploration of systems at all levels. Now it is useful to consider the basic concepts of the systems approach and relate them to FSRE.

The fundamental tenants of a systems approach may be set-out as follows:

1. Define the boundary of the system to be studied.
2. Define the relevant sub-systems and the hierarchy in which they are placed.
3. Analyze the sub-systems and interactions between them by experimentation or observation.
4. Understand sub-systems that provide the building blocks for the total system.
5. Systems synthesis—drawing the sub-systems together—usually by modelling.

There are two important issues here for FSRE. The first is concerned with definition of research priorities; the second with issues concerned with the transferability of knowledge.

The prospect of targeting research resources more effectively. Within a systems hierarchy of sub-systems and sub-sub-systems, it is important to define those that form the appropriate bottom level—the finest relevant amount of detail. These are sub-systems for which a clear understanding of structure and function is essential to an operational appreciation of the system defined at the top of the hierarchy. For a crop production system, sub-systems representing, say, soil-water dynamics may be required. On the other hand, for rural community systems, a sub-system dealing with the dynamics of household decision-making may be one of those at the base of the hierarchy—soil water subsystems may represent an unwarranted level of detail.

The issue at the heart of the problemis where research efforts should be directed. Research aimed at gaining a clearer understanding of sub-systems below the relevant bottom level of the hierarchy is likely to have poor pay-offs in terms of the goals for the main system. For example, in semi-arid areas in Southern Africa where concern is with improvement in the social welfare of communities, it may be said that sub-systems concerned with ruminant metabolism are just too far down the hierarchy to warrant research attention. Research into sub-systems dealing with grazing property rights in communal lands, on the other hand, may be at the right level to be targeted. Such research may provide opportunities to improve the welfare of village communities. Unfortunately, both science-led and technology-driven research have usually been directed below the relevant bottom-line of sub-systems. Consequently, a lot is known about detailed science-based systems and relatively little about the wider social systems in which they are embedded. Research into farm livelihood systems and rural community systems is likely to bring increasingly rapid pay-offs if directed at socio-economic and socio-cultural sub-systems.

It is important to recognize here that the debate is not about relatively minor shifts in research resource allocation but rather major changes in research orientation with different skills and different disciplines becoming involved.

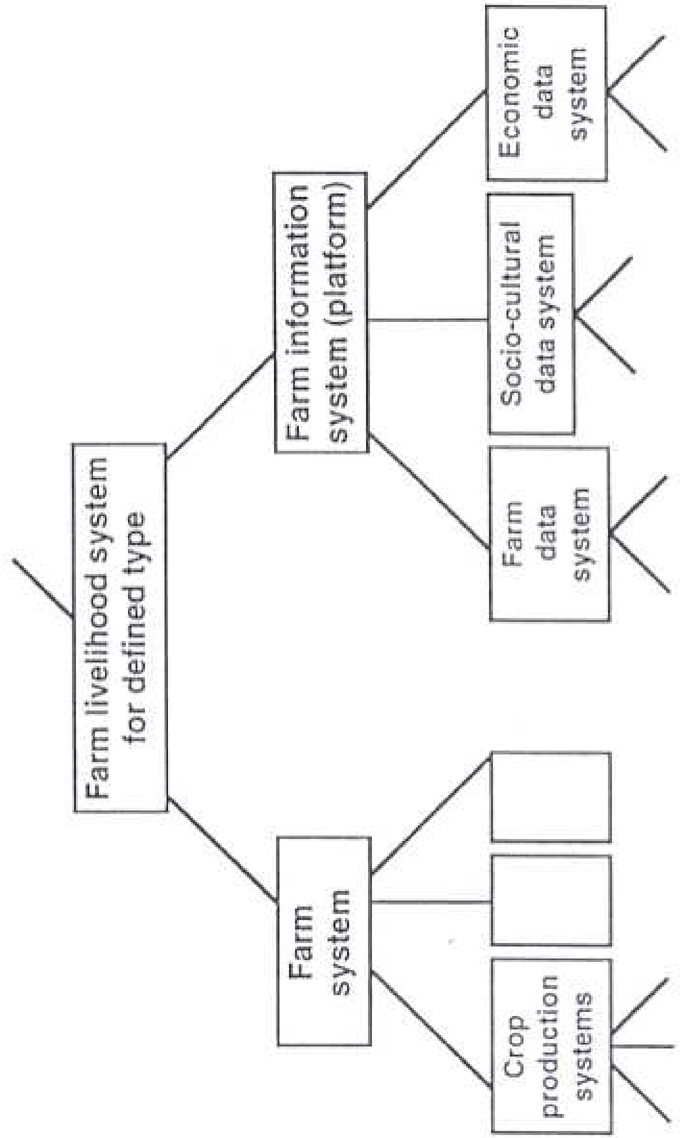
The prospect of transferring knowledge. Systems theory implies that sub-systems are autonomous within a defined boundary. If this is true, such sub-systems should be capable of being applied within a range of systems hierarchies. Thus it should be feasible to transfer knowledge within a sub-system (or at least the sub-system structure) from one location to another. Furthermore, research may be carried out on such systems in various locations by different teams and apply the findings in other locations. This is an approach well recognized in conventional science research but FSRE has been driven by case applications of the FSRE art. There is now a need, relevant to rural systems, not only to improve the efficiency of the development process but also to look for more rapid solutions to problems.

Roling (1994) has defined just such a paradigm (sub-system structure) that has application at a number of different levels. He distinguishes between the actual system on the one hand and the 'platform' for decision making about the system on the other. Others have expressed the same concept in terms of the actual (bio-physical) system and the information system used to manage it. Each, in this case, is more properly defined as a sub-system. Roling (1994) illustrates this by instancing at the farm level, the farm household as the platform and it interfaces with the farm production system. At a more communal level, a group of farm families with a common problem and with common aspirations represent the bio-physical domain, while the platform consists of the collective decision making representatives of the farm and other households involved. Figure 2 shows the systems hierarchy for application at farm level.

The platform that may operate at the communal level as well as at farm household level is a crucially important concept that has had even less research attention than issues related to research prioritization and transferable knowledge within sub-systems. The nature of the platform (its structure, components, and mechanisms) has hardly been analyzed. Figure 2 implies that in any given circumstance (that is for any class of farm household), social, cultural,

Figure 2

SYSTEM HIERARCHY



and infrastructural elements will determine at least the componentry of the platform. Only the most general view of the actual mechanisms of the decision process are available.

Figure 3 offers a farm-level view of this vital ingredient for FSRE. The platform here is hypothesized as a nested group of decision support systems (Dent, 1994). The farm family has a number of objectives (some specific, others general) falling under the headings of technical, social, and economic. Information concerning each of these is perceived by the farm decision making unit by way of various pathways. A second hypothesis is that providing such information indicates that objectives are being met, then the decisions made will generally coincide with those made during the last production cycle (last season).

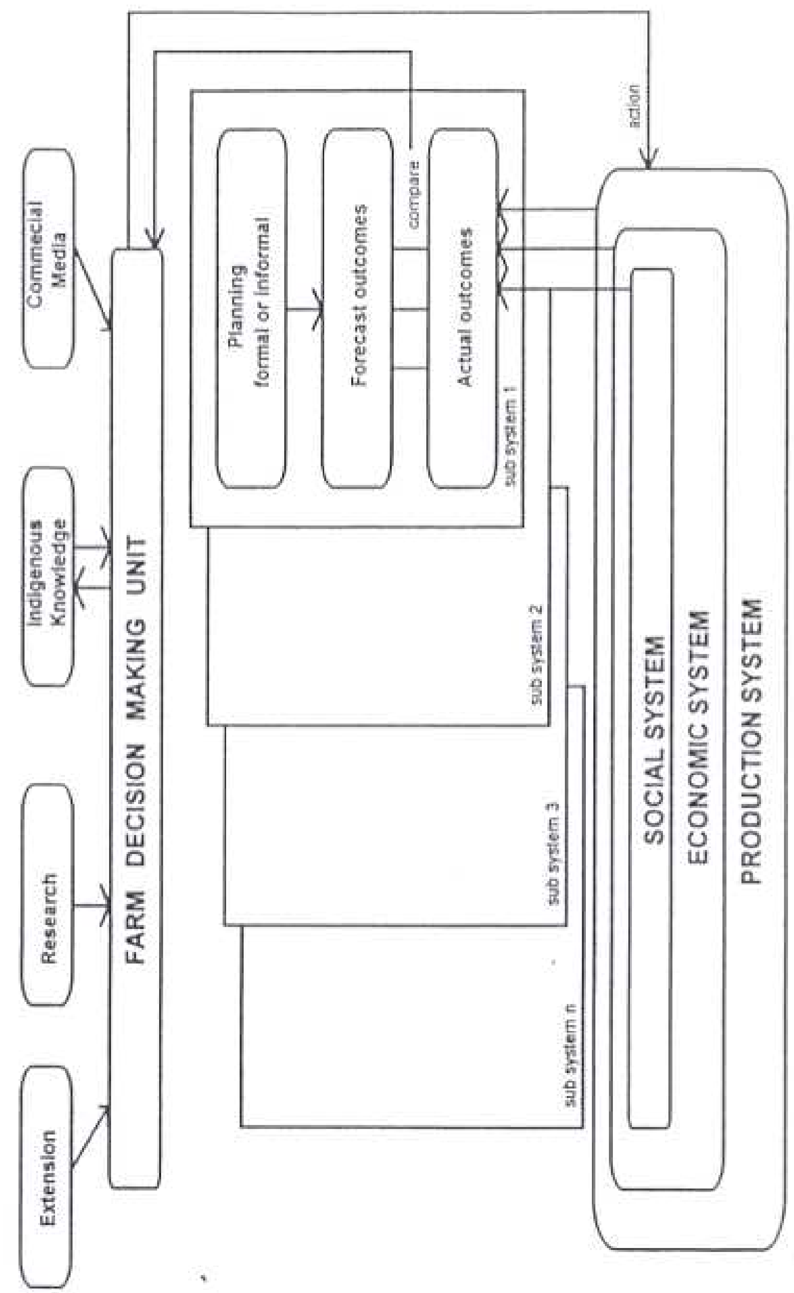
This implies that the decision making unit not only has a view about its objectives but also monitors in some way (mainly informally) the extent to which these objectives are being fulfilled. When one or more objectives are not being met then corrective action will take place. In some circumstances, the platform involved is extremely simple, with maybe only one or two decision support systems functioning. For example, in a highly capitalized and intensive European farm system, the economic performance indicators are likely to override most others. More complex situations may be the norm in other places where cultural objectives and perhaps subsistence nutritional levels for the family may be paramount.

In passing, it should be noted that these kinds of processes can be relatively easily constructed into formal models using 'rule of thumb' and qualitative data within formats suggested by expert systems methodology.

It seems only a minor logical step to conclude that FSRE procedures should be directed only toward decision support systems that are 'active' for a group of farms. Indeed, it can be supposed that farm livelihood systems may be satisfactorily classified relative to the decision support systems that apply. Perhaps herein is a prospect of grouping farms within an agro-climatic zone according to useful operational characteristics. It can be argued that adaptive research, whether at farm technology level or at institutional level (i.e., infrastructure or people empowerment), will only be successful if it reinforces existing and operational decision support systems. Similar comments may be directed towards rural policy; to be effective it must bear directly on active decision support systems.

The concepts of platforms, the mechanisms of decision making, and the hypotheses involved are a far cry from conventional notions that farm families seek to attain the best financial performance or even specifically high levels of security and organize their resources accordingly. But the fact is that little is known about the decision-making process and this is a stark contrast with extensive and detailed knowledge of the biological components of rural systems.

Figure 3



This debate has touched one paradigm that may be transferable and may indeed operate at a number of levels in organized society. This is but a single example and illustrates the kind of research and its orientation and the kind of approach to modelling that is now required. Other such paradigms easily come to mind: researching unsatisfactorily defined property rights; motivation and empowerment models for women; and creating infrastructural safety nets for rural communities in regions of extensive climate variability.

CONCLUSIONS

The discussions have highlighted a number of issues pertinent to rural development and have attempted to show the relevance and use of modelling.

1. It is questionable whether rural development should be addressed at the farm level.

2. A systems framework is appropriate for rural development research and action. Such work needs to be people oriented rather than technology driven.

3. Modelling is intrinsically part of the development process and more formal methodologies have advantages over conceptual models. Newer modelling techniques can utilize qualitative data and can mimic behavior patterns of individuals and communities.

4. More explicit use of modelling encourages the definition of concepts into general paradigms and theories. It may also encourage more attempts to put some order into sociocultural heterogeneity (classification). Both of these may assist in the transference of knowledge from one region to another.

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