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Etud. Rech. Syst. Agraires Dév., 1997, 30 : 151-167

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Marginal in the first paradigm, core in the second[1]

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Résumé

Recherche-Action et gestion des ressources naturelles: marginalité dans le premier paradigme, centralité dans le second. Notre article se démarque de l'hypothèse qui voudrait que la recherche action ait acquis un statut de méthode confirmée d'apprentissage interactif et de gestion de processus d'évolution complexes. Nous tentons d'aller au-delà en confrontant de façon systématique deux paradigmes, ceux du constructivisme et du positivisme. En théorie, chacun de ces paradigmes possède une forte cohérence interne à différents niveaux du discours: épistémologie, théorie, méthodologie. En pratique, nous vivons dans un temps d'évolution et de confusion paradigmatique. Ce chapitre confronte les deux paradigmes pour tenter de résoudre cette confusion et de clarifier la situation. Il traite essentiellement du second paradigme qui paraît apporter des éléments essentiels pour gérer les évolutions requises par un développement durable. Cette évolution n'est pas le seul fait de la technologie ou des forces du marché, mais exige nécessairement de faciliter l'apprentissage collectif et l'instauration d'accords négociés. La recherche-action est une approche clef permettant de gérer le changement dans ce second paradigme. Ce chapitre ne réfléchit pas seulement sur ce second paradigme, mais tente aussi d'en tirer des enseignements pratiques en matière de gestion.

Mots-clés : positivisme, constructivisme, gestion du changement, développement durable.

Abstract

This chapter departs from the assumption that action research has become an established methodology for interactive learning and the management of complex processes of change. It tries to go further by systematically contrasting two paradigms, positivism and constructivism. Theoretically, these paradigms are each highly internally consistent across different levels of discourse, such as epistemology, theory, and methodology. In practice, we live in an era of paradigm change and confusion. The chapter contrasts the two paradigms in an attempt to resolve the confusion and provide clarity. It focuses especially on the second paradigm, because it seems to provide the essential understanding for managing the change required for sustainable development. This change is not brought about only by technology and market forces, but necessarily requires facilitation of collective learning and negotiated agreement. Action research is a key methodology for managing change in the second paradigm. The chapter not only elaborates this paradigm, but also pragmatically tries to draw the implications for management.

Keywords: *positivism, constructivism, management of change, sustainable development*

[1] Some of the ideas in this chapter have previously been published in N. Röling and P. Engel 1995; Röling, 1996; and J. Jiggins et al., 1995.

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1. Introduction

The context for agriculture has changed so much that it is evoking a paradigm shift in agricultural science. Some go so far as to say that agricultural science as it is today is part of the problem, not part of the solution. That is, if we attempt to take up the challenges that face agriculture today with the old responses, we only make matters worse.

That is strongly put. And, as we shall see, it would be foolish to throw away all the achievements of the past in the search for the new and push the new idea at the expense of the old. But, in our search for the essence of the changes that have taken place, we do need to emphasize the differences and contrast the old and new.

This chapter seeks to create clarity by clearly contrasting two paradigms, the first inspired by positivism and the second based on constructivism. In doing so, it shall become clear that the second paradigm encompasses the first and does not nullify it. We focus especially on the second paradigm, not so much because we advocate it for its own sake, but because we believe it makes an essential contribution to society's ability to respond adaptively to environmental feedback to human activity which we see as the central survival issue of the day.

A discussion of paradigms is practical. Their tenets underpin decision making about investment in research, the training of scientists, the organization of the agricultural knowledge system, and the management of knowledge processes. They also guide the expectations of policy makers and farmers about science's contribution to technology development and innovation, and colour the networks of social action within which science is embedded. In the new paradigm, action research moves from being a marginal activity to a central one.

The chapter first describes the paradigm which presently underpins agricultural science. It then looks at the changing context for agricultural science and at the paradigm which emerges in response. The subsequent section examines the transitions taking place and describes the new-style agricultural science, especially the role of action research. The chapter concludes with implications for investment and management.

2. The first paradigm

The successes of agricultural science in developing our highly productive 'science-based agriculture' have been driven by the first paradigm which still largely determines decision making about agricultural science and technology development.

At the base of this first paradigm is an epistemology, a set of assumptions about the nature of human knowledge. The word 'epistemology' is usually dismissed as jargon by those who hear it for the first time. The technical term for the epistemology underpinning the first paradigm is 'naive realist positivism' (NRP), jargon with a vengeance. Bear with us and fill the small test below to see whether you are an NRP yourself (Box 1).

▪ reality exists, independently from the human observer.	[true] [false]
▪ by carrying out scientific research, we can develop objectively true knowledge about reality.	[true] [false]
▪ scientists discover new knowledge, they lift the veil, and reveal nature's secrets, laying bare the naked truth.	[true] [false]
▪ the role of science is to accumulate a body of knowledge about how the world is.	[true] [false]
▪ scientific research is the source of innovation.	[true] [false]
▪ technology is applied science.	[true] [false]
▪ our environmental problems can only be solved by scientific knowledge.	[true] [false]
▪ the government must invest heavily in scientific research	[true] [false]

Box 1: Test for naive realist positivism

Though the test is not based on a scientifically validated scale, we believe that anyone who scores 'true' for 5 of the items can be considered an NRP. It is not a fatal affliction, but it has some drawbacks. From the point of view of responding to environmental feedback, NRP reduces societies' and individuals' degrees of freedom in adaptation. Here are some examples.

Belief that there is one objective truth based on an established body of knowledge, and set procedures for discerning and testing the validity of knowledge claims, implies that anyone who holds other views, or views based on other procedures, is wrong. Wrong views are dismissed or negated; they do not count (Maturana, no date). One can try to convince people on the basis of scientific reasoning and evidence, but if they persist in thinking otherwise, that is about it.

Agricultural science, as all bio-physical sciences, is embedded in the first paradigm. It has been able to establish laws in nature and has given rise to technology for instrumental intervention. One can send a person to the moon with that science. It is the basis of our mass wealth, agricultural productivity and - industrial goods. The experience of this enormous achievement has led to the belief that there are technical solutions to most of our problems. Hence, it is argued, the task of applied science is to look for the 'best technical means' to reach societal goals. Science does not need to bother much about the goals themselves or the values and choices embedded in them. It promises escape from the miseries of hunger, hard labour, disease and discomfort. Instrumental control over the bio-physical environment is seen as the basis of our success as a species and for a wealth which could be shared by everyone.

From this perspective, the social sciences have not been able to develop objectively true knowledge of comparable universality and power of prediction and intervention. With social science one cannot send a person to the moon. What is considered important in social science from the perspective of the first paradigm is science communication, which can transfer the knowledge developed by science to users and public. 'If all that is known in the world were applied, we would not have the problems of under-development and misery facing us today'.

This perspective has reinforced the general acceptance of the linear model (Kline and Rosenberg, 1986), especially in agriculture. According to this linear model, science develops innovations which are transferred by extension agents to farmer-utilisers. Science-based agriculture is seen as the main weapon against food insecurity. We must, therefore, create an effective knowledge system, institutionally calibrating the science-practice continuum (Lionberger and Chang, 1970) and facilitating the diffusion of the innovations developed by scientists (Rogers, 1983).

Are we far wrong in this sketch of the mind-set of the NRP? We believe not. Box 2 summarises the first paradigm.

▪ Epistemology	naive realist positivism
▪ Perspective on truth	one objective truth
▪ Nature of rationality	instrumental, technical
▪ Objectives	unambiguous, unequivocal
▪ Systems perspective	hard systems: best technical means to achieve pre-set objectives
▪ Planning	blue-print, top down
▪ Policy process	policy is developed by experts, emphasis on compliance and on creating a conducive public opinion
▪ Role of research	source of innovation
▪ Nature of science	bio-physical science, social science marginally influential
▪ Role of extension	transfer of knowledge

Box 2: Overview of the main characteristics of the first paradigm

3. Emerging challenges for agricultural science

We have entered a new phase in the human condition which brings into play a second paradigm as the framework for agricultural science and technology development.

1. *The goals for agriculture have changed from a single focus to multiple, often conflicting goals.* In addition to increasing productivity and competitiveness, goals now comprise sustainable resource use, environmental protection, bio-diversity, landscapes values, equity, employment, viable rural communities, recreation and stability (after Conway, 1994). These multiple goals ask for a re-negotiation of the role of agriculture in society (Bloome, 1991). To support an agriculture with multiple goals, agricultural science also must change.

2. *Imposing purely technical solutions is seldom enough to solve our problems. Most of them require complex negotiation and/or agreement.* We are no longer only battling primary nature, we are especially dealing with second generation problems that result from an instrumental command of natural forces. Our present challenges are less concerned with people-nature relations that need instrumental management, than with people-people relations that need interaction, i.e., strategic or communicative management. This holds especially with respect to the human use of natural resources. Our 'wants' have changed because food now requires so little of our income that we can move up the hierarchy of needs. But our 'gets' have especially changed; our harnessing of nature threatens to destroy our biotope. More correctly put: exploitation of natural resources by some is increasingly contested by others. We need to adapt our consumption to what others consider acceptable. George Bush's claim at the United Nations Conference on the Environment and Development that the American style of life is not negotiable only underscored the political nature of what is presented in the first paradigm as a purely scientific and technical challenge. After years of unbridled search to adapt gets to wants, we increasingly have to negotiate our wants. Technology can shape the terms of that negotiation, not get us out of the predicament.

3. *Our reliance on experts and specialist institutions is waning.* Recent research (Tate, 1995) shows, for example, that British respondents would not trust information about bio-technology from scientists, industrial firms or the Department of Trade and Industry, but rather from activist groups such as Greenpeace. Funtowicz and Ravetz (this volume) have coined the term 'Post-normal science' for the present situation. The sciences which got us into our current mess cannot be expected to get us out it. That is not to say we do not need scientists anymore. Far from it. But the new situation asks for a democratisation of science. Facts have been extended to include what people want and value, peer communities have been extended to include self-appointed activists, and science is 'popular' in that ordinary citizens feel sufficiently informed by their own as well as experts' observations, theory forming and testing, and by their own experience of hazard and risk and tolerable degrees of probability, to make their own choices (Brown and Mikkelsen, 1990). The future depends on citizens no less than policy-makers and experts getting it right and hence at the practical and methodological levels on mechanisms of social learning.

Within these larger changes, agricultural science is facing a number of specific new challenges:

- increased export competition, leading to pressure on farm incomes, and to anxiety among the companies, services, and agencies which depend on a healthy primary sector. Innovation occurs along the production-marketing chain, not just in primary production;

- uncertainty added by the new GATT rules;

- declining government expenditure on agriculture, as public sector funding comes under pressure everywhere;

- at the same time, growing disenchantment with 'big government', and privatisation of public services.

These economic and financial pressures in turn have been associated with :

- increasing social stress in rural areas. The sharp reductions in the number of farmers, farm workers and farm services have affected the viability of rural communities and businesses. As the numbers fall, the political clout of the rural sector has been reduced.

Meanwhile, the deterioration in the built environment and the degradation of natural resources are raising new questions for agricultural research, producers, and agribusiness :

- Public tolerance of heavy chemical use, intensive farming methods, chemical residues in food, practices such as womb-renting, and "destructive" landscape changes, is declining. Agriculture is under pressure to clean up its act and to adopt more knowledge- and management-intensive practices. Though such 'intangibles' might not immediately deliver a monetary return, they increasingly appear to be a condition for staying in the market.

- GATT rules on International Property Rights, and ongoing negotiations under the Bio-diversity Convention, are establishing new legal and trade protocols governing e.g., plant collection, gene banks, seed royalties, and genetically engineered products and processes.

4. The second paradigm[3]

The changing experiential context is giving rise to a second paradigm. A debate on its nature, rigour and relevance is in full swing; there is no closure on the implications of its epistemology for professional discourse and practice, nor on the methodological requirements of its practice. But it is becoming increasingly obvious that an agricultural science which underpins sustainable resource use must take cognisance of the second paradigm, because sustainable resource use requires both behavioural change on a wide scale and, in a divided world, socially negotiated acceptance of how resources shall be allocated and used. One of the driving forces of its emergence is the excitement and enthusiasm that accompany liberation from the restrictions imposed by the first.

We start again with the epistemology which underpins the paradigm. It is called 'constructivism'. Reality is no longer seen as existing outside of, and independently from, the human observer. It is socially constructed and emerges from interaction within human communities. That is not to negate the existence of a tangible, 'real' world, merely to emphasise that human knowledge is not an objective projection or reflection of that real world on the mind, as NRPs would have it, but an active creation based on experiential learning, norms, values, and societal arrangements. Social reality construction is the adaptive mechanism *par excellence* by which humans learn to adapt to circumstance.

If people reach consensus on a socially constructed 'life world' (Long and Long, 1992), that life world seems like an objective truth. There is no other. But when they experience contact with other life worlds, they have to make the choice between, on the one hand, fundamentalism and negation, and tolerant acceptance of reality as a matter of negotiation and agreement, on the other. It is perhaps a significant straw in the wind that the US Supreme Court recently came to the conclusion that there is no absolute standard for 'scientific' which can sustain a legal test of truth in court. What is scientific depends on agreement among peers. Science is one of the ways in which reality is socially constructed (Knorr-Cetina, 1981 and 1995; Latour, 1987; Collins, 1992).

In the first paradigm, we have established through experimentation and empirical study that psychological mechanisms,

[3] We are, of course, not the originators of the thoughts underpinning the second paradigm. Many philosophers, scientists, and practitioners have contributed to the emergence of these ideas. We ourselves have been influenced by the teaching of David Berlo, who was Chairman of the Department of Communication at Michigan State University when Röling did his PhD there in the late sixties, and both of us have been 'impressed' by the work of the 'Hawkesbury School', now the University of Western Sydney (e.g., Sriskandarajah *et al*, 1989; Bawden and Packam, 1991; Russell and Ison, 1991).

such as selective perception, reification, projection and wishful thinking can distort objective truth. In the second paradigm, knowledge is accepted as a human creation; people adopt rules to facilitate inter-subjective agreement, but that does not negate the overwhelming evidence of the creative nature of knowledge processes.

Some leading scientists have acknowledged this point explicitly. 'Science is not about building a body of knowledge, but about formulating fresh perspectives' (Bohm, 1993). 'A quantum world does not exist. What exists is a quantum physical description. It is, therefore, wrong to think that it is the task of physics to find out what nature is. Physics deals with what we can say about nature' (Niels Bohr, in French and Kennedy, 1985).

This epistemology has far-reaching implications. Instead of the source of innovation, research becomes one actor in interactive processes from which innovation emerges (Figure 1). From a focus on a civilising *'vulgarisation'* of science, the emphasis shifts to facilitating adaptive reality construction, collective learning to deal with shifts in the human predicament, and negotiation to realise collective action.

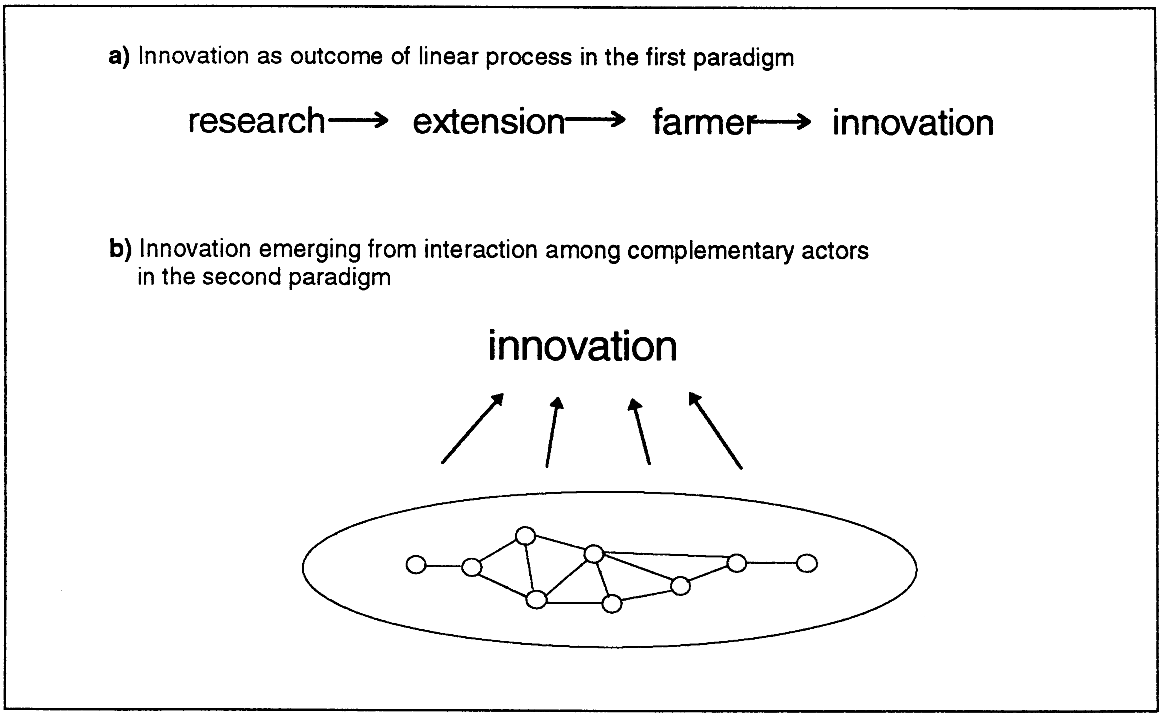

Figure 1: Two approaches to innovation

The moment the task of science is no longer seen as creating a body of objective knowledge, but as formulating fresh perspectives and of exploring 'what we can say about nature', social science acquires a role of its own (Leeuwis, 1993). It is powerful in providing fresh perspectives and in making visible the societal bottlenecks that keep us from making forward-looking adaptations. Where the improvement of problem situations is becoming less dependent on instrumental reasoning and intervention, and more on 'consensual approaches to conflict resolution' (Susskind and Cruikshank, 1987), social science contributes by analysing the 'arenas' of struggle, by facilitating interactive processes, and by contributing to the collective design of the future. It can also underpin activism by developing and testing methodologies for participatory development, and for facilitating processes that can help actors with multiple perspectives and conflicting objectives to agree on collective action. Soft Systems Methodology (Checkland, 1981; Checkland and Scholes, 1990) has been very influential in this respect, especially where it comes to industrial innovation and management. Action research may be considered part of the methodological portfolio appropriate to the management of research, technology development and innovation in agriculture. Box 3 provides an overview of the second paradigm.

▪ Epistemology	constructivism
▪ Nature of truth	multiple perspectives, diversity
▪ Nature of action	strategic/communicative
▪ Goals	multiple, often contradictory
▪ Nature of systems	soft system: learning path to reach a situation in which collective action can be taken
▪ Planning	interactive process
▪ Policy process	emerges from interaction among stake-holders at different levels
▪ Role of research	active partner in societal sense making
▪ Nature of science	bio-physical and social sciences both contribute to adaptive perspectives and action
▪ Nature of extension	facilitation of learning processes

Box 3: Overview of the main characteristics of the second paradigm

5. The danger of constructivism: relativism

Relativism at first glance appears to be inherent in the second paradigm and, as such, to undermine the acceptance of constructivism as a useful epistemology. It seems all too easy to accuse constructivists of assuming that every construction can be deconstructed, that experimentation is irrelevant, and that all concern for the environment can be de-constructed as informed by vested interest and power politics.

We deliberately wish to distance ourselves from such relativist positions and to draw on the work of two Chilean biologists, Maturana and Varela (1992) in so doing. They investigated how organisms can observe. Their research shows objective projection of the environment on the central nervous system to be impossible. In fact, the nervous system is an informationally closed system with respect to its environment.

"*....the interactions between organism and environment will consist of reciprocal perturbations*" ... "*In these interactions, the structure of the environment can only trigger structural changes in the organism (it does not specify or direct them) and vice versa for the environment. The result will be a history of mutually congruent structural changes. As long as the organism and its containing environment do not disintegrate, there will be structural coupling*" (p. 75).

One can compare the nervous system with an airplane that flies in the mist on its instruments. The instruments operate electronically and are governed by different rules than those that govern the environment in which the plane flies. The instruments form a closed system and 'objective' projection of the environment on the electronic instruments does not occur. There are, however, coupling mechanisms which make possible adaptive action by the plane. But it remains a vulnerable business. The structural coupling mechanism, that is, the interpretive and information exchange mechanisms can fail, or the structure of the environment or of the plane can change in ways which no longer trigger congruent action.

When the nervous system is considered informationally closed, it is people, as individuals and in community with others, who actively and creatively construct and invent the concepts, theories and technologies by which they survive and flourish. Reality is neither revealed nor discovered by these processes. But that does not automatically imply relativism. People, and indeed society, can get it wrong and fail to make adaptive adjustments to environmental feedback.

That is why Maturana and Varela define knowledge as "effective action in the domain of existence" (p. 29).

6. The second paradigm: a key to sustainable development

A blind spot affects thinking about sustainable development. That blind spot has to do with the management of change and with the enhancement of societal responsiveness to environmental feedback. To identify this blind spot, we first look at the accustomed ways of thinking about change.

The biophysical sciences have given us the tools to affect causal relationships, the tools for instrumental change. They have allowed people to control things and natural processes to an unprecedented degree. But environmental problems are not so much about technology as they are about human activities. A purely technical approach is insufficient to get us out of our environmental predicament (Röling and Wagemakers, in press).

Neo-classical economics is a body of knowledge and practices concerning change. It assumes that the market is the main mechanism to guide society in the 'right' direction. But environmental economists (e.g. Van Ierland, 1996) readily acknowledge that there are a number of situations in which the market fails. Common property resources, such as community-managed grazing land, are destroyed by market competition. The market also does not work when the negative effects of activities can be externalised without compensation. Uncontrolled emissions of waste products and pollutants are a typical example. A third situation is represented by collective goods, i.e., goods from the access to which no one can be excluded, so that their use cannot be arranged via the market. An example is the global climate. A fourth situation is the perfect market, approached by agriculture with its many competing firms, none of which can control prices. Though agriculture so closely resembles the ideal of economists, it is notoriously characterised by grave discontent and hardship (Galbraith, 1995). Where the market fails, economists counsel society to deploy regulatory and/or fiscal policy measures.

And that counsel fails to perceive other important opportunities for beneficial and voluntary societal change: the understanding and facilitation of knowledge processes, of (collective) learning, of problem directed interaction and debate, and of negotiated agreement on action.

The blind spot hides a vital area in the management of change; it is an area that is increasingly important as influential thinkers embrace constructivism, and as professionals, practitioners and activists turn to Participatory Policy Analysis, Participatory Technology Development, Participatory Learning and Action Research and other approaches, and their associated methodologies, which rely on learning and facilitated interaction. There is an increasing realisation that sustainability is not the objective attribute of an eco-system, but an emergent property of a soft-system, that is, the outcome of negotiated agreement (Bawden and Packam, 1991; Korthals, 1994).

The philosopher Jürgen Habermas (e.g., White, 1988 and Brand, 1990) sees two ways by which social actors mutually adjust their activities:

(1) on the basis of communication and hence through argumentation, rationality, norms, values and agreement, and

(2) on the basis of mediation through money, exchange, and power.

In the former case, one looks at society from the perspective of actors and stakeholders and the way they give meaning to things and events. Things happen because people have reason for them to happen or have agreed that they should happen. Habermas calls this 'the life world perspective'. One can also speak of 'soft systems thinking'.

In the latter case, one looks at society as a whole and at its functioning. In that case, one handles a 'hard systems perspective'. Hard systems are bits of society which have been de-coupled from their basis in meaning and which operate normlessly on the basis of their own inherent laws. They are not or not significantly driven by the life world.

In the life world, coordination is above all communicative. In the hard system, coordination is essentially mediative. Both mechanisms operate at the same time and interact.

The optimist assumes that people can agree to construct a sustainable future and learn their way towards such a future. This makes the optimist interested in the social (re)construction of the environment and in methodologies and methods for the management of voluntary change through collective learning. That is, the optimist operates from a life world perspective, but knows full well that a sustainable future is possible only with the support of the other mechanisms of societal adjustment such as regulatory and fiscal policies.

If we give the impression that we are advocates of the second paradigm it is because we want to call attention to the described blind spot in thinking about the management of change. Hard instrumental approaches and reliance on a self-regulating market driven by selfish individual decisions are widely recognised not to be sufficient for solving complex environmental problems. The second paradigm provides a way to move from recognising insufficiency to embracing forward-looking strategies.

7. The second paradigm comes of age in terms of its coherence across levels of discourse

The shift in paradigm is manifesting itself first in adaptations of procedures, working methods, etc. Thus participatory methods, such as Participatory Rural Appraisal are being applied experimentally in the field, workshops with farmers are organised as scientists seek to develop the institutional arrangements for 'knowledge partnerships', and pilot pogrammes seek strategies to 'give farmers ownership' of the development process.

These procedures and working methods are increasingly being elaborated in manuals (e.g., Pretty *et al.*, 1995) and in methodologies and strategies for sustainable farm development, such as in Participatory Technology Development (e.g., Jiggins and de Zeeuw, 1992), Integrated Pest Management (e.g., Röling and Van de Fliert, 1994) and in minimal tillage (Hamilton, 1995).

But the shift in paradigm also leads to fundamental rethinking of the methods of enquiry, i.e., the tools of science itself (Pretty, 1994). Agriculturalists are turning, for example, to symbolic interactionism (Wagemans, 1987), to avoid extracting causes of social events based on 'objective' quantitative research methods, and to understand them from the perspective of people's meanings and reasons. Guba and Lincoln (1994) perhaps have gone furthest in thinking through the implications of a constructivist epistemology for the fundamental assumptions governing the business of research and technology development. Thus they replace such criteria as reliability and validity, which mark a positivist epistemology, with criteria such as trustworthiness and authenticity.

In all, the second paradigm is emerging as a coherent whole covering different aspects of applied theory and practice (Box 4). But it will be some time yet before this whole is taught systematically in high schools, colleges and universities (Jiggins, 1994; Ison, 1990), and before it starts seriously to inform the policies, design, and management of (environmental) research.

Efforts to support social learning and interactive innovation tend to be difficult to scale up. A key reason for this general experience is that the efforts are hindered by philosophical assumptions, decision models, funding procedures, institutional structures, management traditions, staff attitudes, leadership styles and so forth, which belong to the first paradigm. Just changing the operations on the ground is seldom sufficient. That is one reason why it is important to place such efforts in their paradigmatic context, in order to identify the concomitant effort needed at other system levels.

In Mali, an attempt is being made with World Bank support to implement this lesson in a programme aiming to make agricultural research more responsive to farmers' needs (Collion, 1994). In addition to using participatory approaches on the ground, the project is creating farmers' representation at all levels of the organisational hierarchy, including a users' committee at the national level, to ensure organisational accountability. Furthermore, farmers' organisations have been provided with access to funds with which to contract farmer-driven research, thus giving to farmers some countervailing power in determining the research outcome. Although actual implementation of an operational system might take years (ESPGRN, in prep.), at least the principle of the need for a system-scale turn-around has been recognised.

▪ Epistemology	constructivism
▪ Philosophy	the life world is guided by communicative rationality which is an alternative to instrumental and strategic rationality (Habermas, 1984;1987); the uncertainty with high stakes inherent in complex environmental problems precludes reliance on experts and specialists and asks for widely shared activism and scientific practice (Funtowicz and Ravetz, this volume)
▪ Research	fourth generation evaluation methodology (Guba and Lincoln, 1994)
▪ Theories about change	social actor network theory; social dilemma theory; actor-oriented sociology
▪ Theories about the management of change	soft systems thinking; interactive approaches to using indigenous knowledge, etc.
▪ Methodologies for managing change	participatory technology development; participatory policy analysis, action research;
▪ Methods	various concrete participatory methods.

Box 4: Coherence of the second paradigm across different levels of discourse

Similar lessons are being learned everywhere. Funding has become more market-led and competitive. Returns to agricultural research have come under closer scrutiny. The question of how and what to measure to determine effect and impact has become more important (Jiggins, 1995; MacLeod, 1995). The various stakeholders in agricultural research are beginning to search for ways to improve their collaboration to improve the impact of funding, to manage competition among themselves and to improve the funding process. This holds, for example, for the Crown Research Institutes in New Zealand, which are seeking new collaborative arrangements with farmers and funders (Paine, in prep., Jiggins *et al.*, 1995), but also in the Netherlands where the development of sustainable arable systems involving a.o., the management of complex nutrient flows across rotations, requires close cooperation between researchers and farmers (Vereijken, 1992, Vereijken *et al.*, 1994). Characteristically, the institutional framework within which this research takes place is still very linear, in fact prohibiting institutions engaged in 'basic research' to have direct contact with farmers.

In short, we need to take into account the complex actor networks or 'theatres of innovation' (Engel, 1995) and the collaborative arrangements (Paine, in prep.) within which agricultural research takes on its new roles. Innovation may be driven by market-led demand, new market opportunity, researcher-led inspiration, community-based activism, farmer organisation priority, industry development, or individual (farmer, processor, wholesaler, retailer, policy-maker, consumer, etc.) entrepreneur. This means that we need flexible linkage arrangements, not a single 'model'. An efficient innovation system is one which has the capability to implement a diversity of approaches and to service multiple goals. Such considerations underpin the current interest in interactive models of innovation and par ticipatory research processes, such as the types of action research discussed in this volume. Box 5 illustrates an approach which assumes innovation to be the emergent property of interaction.

> The knowledge system (Röling and Engel, 1991) is a construct which is useful for looking at 'theatres of innovation' because it makes visible shortcomings in the composition of the actor networks involved, in their collaboration, or in other aspects which keep them from reaching synergy. The knowledge system is a soft system; innovation emerges from a set of actors who manage to get their act together and make complementary contributions to the same objective.
>
> The knowledge system fits the second paradigm. It assumes actors with multiple perspectives and conflicting interests, but increasingly interdependent outcomes. It focuses on how these actors can move along a learning path, which assumes negotiation, accomodation, conflict, contracts and agreements. Failure is likely, success increasingly a condition for dealing with the ecological imperative.
>
> The knowledge system perspective has spawned two products which are worthy of note here. The first is RAAKS, a participatory action research methodology which allows complementary actors in a theatre of innovation to develop their collaboration to a point where they can take collective action to improve the problem situation (Engel, 1995).
>
> The second is the 'platform for resource use negotiation' (Röling, 1994 a and b), a heuristic and diagnostic perspective for situations where decision making must be scaled up to the ecosystem level at which sustainable management is considered feasible. An example is the creation of a platform for negotiating watershed management.

Box 5: The knowledge system perspective

8. Implications for investment and management

Funders of research typically invest in a packet of activities with fixed goals and objectives, a limited range of predetermined actors, and finite time horizons, i.e., the investment pattern is predicated on the linear assumption that given inputs lead to determinable outputs, and that the pathway for achievement of goals can be specified in advance (Jiggins, 1995). Management concerns focus on efficiency of resource use, which is fairly easy to identify and measure, and sometimes also on effectiveness as a measure of whether the approach, technology, or project does in fact do the job it was designed to do. Impact assessment procedures assume that the intervention (the research project) is the largest source of variance in actual outcomes.

The second paradigm requires a different pattern of investment, and different management and assessment procedures. The investment process must begin with support for identification of stakeholders, and activities to build among them a shared vision of the nature and state of the resource to be managed, the problems associated with current resource management, and what they would like the resource to look like (i.e. its 'emergent properties') at a given future date. The process typically involves clarification of areas of agreement concerning the information and data sets available for scrutiny, but also areas of disagreement where further investigation, data-gathering, or monitoring in the NRP tradition is needed.

The action research process which then unfolds might be described in terms of a guided random walk, with periodic revision of the pathway in the light of organised feedback on key societal and natural processes. It is predicated on an understanding of the relationship between natural resource and societal processes as a dynamic coupled system. Intended outcomes are describable in terms of Bayesian probability; the initial expectation that any one outcome will be achieved is modified iteratively in the light of what actually happens.

The probabilistic nature of events in turn implies that standard research management tools, such as pre-project determination of fixed targets and milestones, typically described in quantitative terms, are inappropriate. Goals, targets, and milestones defined within the second paradigm are rather to be seen as dynamic responses to an unfolding process, expressed as a broad range of measures, both quantitative and qualitative, which are iteratively re-negotiated in the light of changing circumstance.

The key management questions change too: are we still moving toward where we want to go, and, do we need to re-define where we want to go in the light of our emerging understanding? Goals, tactics, strategy, and measures of achievement are all likely, and rightly, to change over time. Commercial enterprises are more used than research establishments to responding in this way to price and sales signals in rapidly moving markets. The second paradigm demands that research establishments respond with comparable flexibility to signals from stakeholders and changes in natural resources.

The distinctions can be taken a little further by examining the implications of funders being included among the stakeholders. Traditionally, agricultural research funders have invested in research *pro bono publico* rather than for their own direct use, while the ultimate end-user of the products of research, the farmer, also has been distanced from the funding body. That is to say, neither funder nor end-user have been connected organically to the actual research process, which thus has been placed in a peculiarly autonomous position, unaccountable to either the investor or the market.

In some cases, commodity levies fund research for the benefit of a specific branch of agriculture, with formal representation of commodity producers on research planning committees. While this has tied funders more closely to the research process, and thus provides in some respects better anticipation of needs or opportunities at least of the more advantaged producers, the model remains linear.

The inclusion of funders as recognised stakeholders in the second paradigm leads to three major shifts.

1. Because funders participate directly in the learning process, they shape (and not merely respond to) the pattern of investment allocation through collective negotiation, to match emerging opportunity.

2. Their direct participation is the only way that their legitimate concern for safeguarding accountable expenditure can be met. Since budgets cannot be set in advance with exactitude, either by item or total amount, iterative, rolling budgeting is required, allowing adjustment to the timing and demands of the moment. This in turn demands investment decision-making as close as practicable to where experience is being generated. Let it be noted that the process does not necessarily preclude commitment to fund longer term, strategic needs. The point is that such needs are identified from within the process by stakeholders, not by a narrower group of outside 'experts'.

3. It follows that the portfolio of investment widens, both in terms of who receives funding and of what is funded. A local environmental activist group is as likely a recipient as the more traditional plant breeder or university department.

There are further implications. The Foundation for Research, Science and Technology, a major public domain funder of agricultural research in New Zealand, for example, has realised that the participation of funders as stakeholders in action research leads to greater emphasis on evaluation and review activities rather than pre-investment appraisal of research projects. The familiar evaluation and review of research results by a scientific peer group at the end of the project period gives way to periodic consideration of (i) process outcomes; (ii) research-in-progress; and (iii) feedback from monitoring, by a broader set of stakeholders, with as much participation by research users as by research providers.

In addition, the question of efficacy assumes greater prominence, as a measure of whether an activity is in fact the right thing to be doing to achieve the collective vision. Assessment of efficacy cannot be an exact science but it serves as a useful touchstone for selecting and prioritising among investment choices and activities, and for deciding collectively whether to terminate or stay with a particular research investment. The muddled consequences of soliciting greater stakeholder participation without an appropriate management framework supports neither good research outcomes nor desired change in society (MacLeod, 1995).

Reflection on the above paragraphs suggests that second paradigm processes cast power issues in a new light. It would be naive to expect that stakeholder participation, soft system methodologies, and participatory processes in themselves obviate power struggles of either personal or institutional kinds. Yet such struggles are manageable, indeed may become both enriching and empowering, if three important lessons are heeded.

1. If stakeholders are encouraged to negotiate resource management on the basis of their present positions, then the process stalls, with no one actor willing to compromise the own power base for the sake of an as yet undefined collective good. However, experience is emerging that it is possible to overcome such impasses by moving from positions to interests and by removing centrally imposed conditions to allow stakeholders to work on local solutions. The subsidiarity principle takes on a crucial position (Susskind and Cruikshank, 1987; Wagemans and Boerma, in prep.).

2. While many resource management problems initially present themselves as problems susceptible to technical solutions, the technocratic assumption typically hides underlying differences in perception of what the problem is 'really' all about and forces premature closure on a limited range of solutions. Much negative energy can be wasted in fighting over technical 'solutions' which prove unacceptable to one or other stakeholder interest, leaving scientists in despair at the apparent irrationality of the public and other stakeholders.

3. It is not sufficient to gather together a range of disciplinary and other expertise considered relevant to the case in hand, in the expectation that an effective and acceptable solution will emerge by virtue of broadening the mix of capacities engaged in finding solutions. Neither the 'interdisciplinarity' nor 'multi-disciplinarity' adequately describes what may be better defined as 'trans-disciplinarity', that is, the need for stakeholders to build together an integrative conceptual framework.

An 'integrative conceptual framework" often is taken to mean a computer-based model. Three computer-based modeling approaches are briefly described here as offering some promise. For example, 'Interactive Multiple-Goal Simulation Models' (Fresco *et al.*, 1994) allow interrogation of policy scenarios from a variety of technical perspectives. But they entirely lack capacity to model the messy real world dynamic exhibited by human systems. There is also limited experience with crop process models, such as generated by the APSRU group of the DPI/CSIRO Division of Tropical Crops and Pastures in Queensland, Australia, which allow farmers and other users to explore, using data for their own farm, the yield and income consequences over time of a range of resource management options in relation to interactive rainfall-soil fertility scenarios. While the approach is both innovative and useful, the effort to establish degrees of accuracy and precision necessary to sustain the model's legitimacy as a scientific tool detracts from the rather simpler demands which would fulfill farmers', advisers', and policymakers' need for insight into a limited range of interactive effects (Ridge and Cox, 1995). The modeling group at Whatawhata Research Station at Palmerston North, New Zealand, is working on a probabilistic model which allows active updating of model coefficients; input of new information from stakeholders; and re-writes of probabilities, values, and weights assigned to relationships, and thus comes closer to representation of the second paradigm.

Notwithstanding the contribution such efforts are making, there are a number of caveats which should be noted. First, they serve the purpose of an integrative conceptual framework only to the extent that all stakeholders are involved in design and interpretation. Secondly, where researchers are largely or entirely responsible for design and interpretation, there is a tendency for them to make claims for accuracy, precision, and generality which cannot be sustained under close scrutiny, i.e., the models become an assertion of power rather than instruments for understanding and learning. Thirdly, as those working with conceptual models of ecological processes are demonstrating, computer-based modeling may prove to be an expensive distraction in the management of natural resources. Indeed, as the experience documented by Scoones and Thompson (1994) demonstrates, there are effective alternatives to high-tech approaches; even illiterate men and women are perfectly capable of generating powerful conceptual models of resource states and trends which integrate societal and natural processes.

Finally, there remains the question of how investment in localised participatory approaches to resource management can be 'scaled-up' to make a difference in terms of the future we are moving towards. There are two distinct ways of stating the scaling problem: (i) as a matter of replication; and (ii), as a matter of reproduction. Replication is a metaphor for scaling as an industrial process, a question of doing the same thing n times over, thus manageable as an administrative task requiring planning support. Reproduction is a metaphor for evolutionary creativity, thus manageable as a multi-sourced opportunity requiring enabling support.

The choice between the two depends in part on how one views human systems, as finite state systems driven by rule sets far from equilibrium, or as tending toward equilibrium. The metaphor of replication fits the former, in the expectation that human systems settle to stability, interrupted by bouts of instability. The metaphor of reproduction fits the latter view, in the expectation that human systems are dynamic and open, and that the best (maybe the only) way to survive in rapidly changing circumstances is for individuals and communities to "learn" the way into the future, with the processes of communicative rationality generating the information which stands as the equivalent of the biological information encoded in genes.

In investment and management terms, to descend from the metaphorical to the practical plane, the challenge is to empower and support emergent 'platform' capacity to evolve at a hierarchy of levels.

9. Conclusions

From the single pursuit of productivity of resource exploitation, agricultural science is being challenged to make significant contributions to the ongoing social (re)construction of the human biotope and to play a role in negotiating sustainable natural resource management. This challenge comprises all eco-system levels, including the planet. In responding to this challenge, agricultural research is increasingly a partner in collaborative arrangements to improve concrete problem situations. Action research therefore becomes a core, rather than a peripheral activity.

The paradigm underpinning agricultural science and technology development is changing rapidly. The conventional linear, 'first' paradigm is incorporated in a more adaptive, interactive, 'second' paradigm. The change has far-reaching implications for financing and management of agricultural research. The question is whether the required adaptations can be made in time. If we continue to work on our future on the basis of the first paradigm, *"le futur n'est pas nécessairement avenir"*.

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