Doing It Together

Technology as Practice in the New Zealand Dairy Sector

M.S. Paine

Doing It Together: technology as practice in the NZ dairy sector

Stellingen

1. Living with complex problems requires a way of muddling through (adaptive management) a labyrinth of uncertain outcomes that emerge from human activities. *(this thesis)*

2. Working together requires an evolving integrity of practice, embodied in repertoires of shared activity. *(this thesis)*

3. Science companies operating in a free market confront a particularly difficult dual social role, being required to underpin efforts by organisations to minimise the uncertainty of achieving their intended outcomes, while stimulating innovation through a dynamic process of inquiry. *(this thesis)*

4. If agricultural science is finding out more and more about less and less, it is for want of working relationships with practices that work in a world of problems and opportunities. *(this thesis)*

5. The fate of extension science in free market economies will depend on its ability to enhance sector and policy appreciation of mediating practices. *(this thesis)*

6. The effectiveness of free market reforms to NZ healthcare systems can be assessed not only as change in the empowerment of patients as clients, but also as change in the reflective activity of medical practitioners.

7. The complexity and confusion embedded in the university system stimulates higher learning when participants grasp the rules for adventure.

8. As the legal system propagates rules for performing new social practices, it changes its own rules of practice.

9. The 'making of new nature' is a Dutch endeavour that can be depicted as the construction of new landuse practices.

10. Perhaps all theories of practice tend, as they rise to their best, as understood by their worthiest representatives, to identification with each other. For the variety of men's possible reflections on their experience, as of that experience itself, is not really so great as it seems;

and as the highest and most disinterested ethical *formulae*, filtering down into men's everyday existence, reach the same poor level of vulgar egotism, so we may fairly suppose that all the highest spirits, from whatever contrasted points they started, would yet be found to entertain, in the moral consciousness realized by themselves, much the same kind of mental company; to hold, far more than might be thought probable at first sight, the same personal types of character, and even the same artistic and literary types, in esteem or aversion; to convey, all of them alike, the same savour of unworldliness. *(Pater, 1986. Marius the epicurean - his sensations and ideas. p152)*

11. The question of the practical use of science then becomes a question concerning the interaction between scientific practices and technical practices. In the interplay model, the interaction between scientific and technical practices is more than just a simple exchange of results between practices. Both kinds of practices are changed in some manner, yet each also maintains its uniqueness and integrity. *(Gremmen, 1993. The Mystery of the Practical Use of Scientific Knowledge, p. 139.)*

12. Given that the development of knowledge is our survival strategy, the capability to adapt to changed circumstances is governed by receiving and interpreting signals and developing appropriate theory and technology in response. An important problem is that, because of their economic and other privileges, elite decision makers often are screened from signals that there is something wrong. *(Röling, 1996. Towards an interactive agricultural science, p. 36)*

13. In any agricultural application it should be, in the first instance, 'learning by doing' (as distinct from the 'participant observation' practised by anthropologists which is often mainly 'learning by talking'). Work of this sort would involve sustained contact with selected farms and farmers over a long enough period to allow the student to understand village agriculture as a process. (The processual aspect often eludes the researcher confined to 'data' recorded in questionnaires or the 'events' witnessed in one-off visits.) No student should expect to be able to advise farmers on changes in their farming practices until he or she has a firm grasp of the issues from a participant's point of view. (*Richards, 1985. Indigenous agricultural revolution, p. 157)*

14. The Dutch international PhD programme excels in a golden rule - giving exceeds receiving.

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Doing It Together

technology as practice in the New Zealand Dairy Sector

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Summary
The economic reforms in New Zealand (NZ) that introduced free market policies following the election of the 1984 Labour Government led to a rapid and extensive reduction in subsidies to agriculture. Over a period of ten years fertiliser subsidies and price support schemes were removed, the government extension service was privatised, and research organisations were restructured to function on a contestable funding basis. The NZ government pursued a policy of joint investment in technology development with the productive sectors benefitting by the development outcomes. These changes provoked debate among science policy-makers and science managers about the way research companies and commercial organisations could collaborate in research and development programmes. The research reported in this thesis responded to a need to progress understanding of the linkage activities currently operating in the NZ dairy sector and thereby assist science policy and science managers operating in the sector to improve linkages with commercial organisations. Specifically, how do organisations and actors link their activities to evolve technology for use in the NZ dairy sector, and how can an understanding of these linkage activities inform technology managers in the NZ dairy sector? The dairy sector was selected as a context with a reasonable likelihood of observing collaboration in technology management.

A case study research design was used to investigate three programmes that involved some form of collaboration between government research and commercial organisations in joint development work. These programmes included: development and marketing of a device (CIDR); developing a sector-wide quality management system (SAMM); developing resource management methods for farming (SSGP). The Grounded Theory methodology was used to study each programme. In particular, this research followed the Glasarian school of Grounded Theory that emphasises the emergence of theoretical perspectives using the constant comparative method of data gathering and analysis. A procedure for questioning and comparison of field data guides the analyst to build and compare theory with other perspectives offered in the literature.

The organisation theory literature has dealt extensively with issues of collaboration and technology management. This literature was reviewed with a view to an agricultural context. Two particularly informative perspectives were identified: Agricultural Knowledge Systems (AKS); and the Interplay Model. The AKS perspective sensitised the analyst to a constructivist view - *theatres of innovation* where actors and organisations negotiate and socially construct their knowledge with respect to their problem context. The Interplay Model emphasised that the emergent properties of collaborative relations among research and commercial entities were primarily a function of activities performed in practices. A specialised notion of practice is used in the model, whereby practice is a way of doing, that if asked, actors would explain their activities in terms of, 'the way things are done around here.' Practices, operating in theatres of innovation, are performed intentionally by actors. The above perspectives were combined by the analyst to investigate case study data in terms of activities performed in what was viewed as theatres of innovation.

The CIDR (Controlled Intravaginal Drug Release) case study documents in four chronological stages the emergence of synchronising technology for managing dairy cow reproduction. Early development efforts were concerned with developing a device, whereas later activities focused on building protocols for treatment. The alignment of activities performed by those actors working on the programme was achieved in several ways. As actors worked together they acquired windows of insight into the practices performed by other actors. When these practices were interwoven with the delivery of professional services, trust and respect were required for the programme workers to collaborate. The Intellectual Property Rights emerging from the programme developments were periodically reviewed and renegotiated by appealing to the notion of a family or club that had a membership of actors from several organisations. The identity of the club provided opportunity to build innovative strategies for performing new development and marketing activities. The CIDR is depicted as contributing towards an emerging practice in the case study, in as much as the device formed part of an expanding scope of development that encompassed several dairy cow synchronising devices, protocols and concepts. Developers used these devices and protocols to embody the rules of synchronising practice. The practice of synchronising enabled developers to cross boundaries that might otherwise be imposed by organisations seeking to lay an independent claim to intellectual property rights. The continuity of emergence in the case of CIDR was worked out by the actors in a process of muddling through. By reflecting on their activities actors learned from past errors and redirecting their intentions accordingly.

The SAMM (Seasonal Approach to Managing Mastitis) case study investigated how a sector wide intervention, operating under free market policies, worked towards mastitis management in the national herd. A series of interventions had been operating in the sector prior to the introduction of SAMM. Indeed, these earlier interventions assisted to 'prepare the way' for the SAMM, in that actors that performed different tasks in relation to managing mastitis in the sector were attuned to problems of mastitis and had developed tools and routines to cope with these problems. However, no specific organisation or profession claimed mastitis management as their domain of work, allowing the formation of a committee (NMAC) that fostered interactive activity to overcome problems of mastitis. The NMAC provided an interface for practices involved in developing interventions. Furthermore, the NMAC used the SAMM to embody the rules of mastitis management, that enabled farmers and others to act on mastitis in a way specific to their farm enterprise. The activities of the NMAC itself constituted a type of practice, referred to as mediating practice. The mediating practice of the NMAC constructed strategies to foster collaboration among organisations and actors. These organisations and actors learnt by reflecting on past errors and combining their experiences in the committee, that itself received institutional support. The dairy companies, who process milk into diverse milk products for export, were members of the NMAC and came to play an increasingly important role in the working out of mastitis management. The dairy companies used pricing policies for raw milk and the provision of information to support their farmer suppliers reduce the level of mastitis in their herds. In the case of SAMM problems were an emergent property of practice. Again the activities of actors were depicted as a muddling towards improved mastitis management, with changes in intervention programmes being wrought out of

reflection on past errors. The mediating practice worked towards the facilitation of improved conditions for working on mastitis management, and for actors to learn and improve management strategies.

The final case study investigated a Sustainability Study Group Programme (SSGP) that was following a participatory approach among farmers, environmentalists and researchers to work out an alignment of resource management and farm production goals. A pair of actors from farming and research backgrounds developed the SSGP and were referred to as programme leaders. These programme leaders encouraged other participants, who worked in farming, resource management and research activities, to join SSGP. Over an 18 month period the activities of the programme evolved methods for farming that helped align production and resource management goals, albeit, with considerable uncertainty about the programme purpose, or prerequisites for collective activity. A crisis of conflict between environmental and farm production aims catalysed a comprehensive effort to redefine the programme purposes. These efforts involved the building of shared needs, working from the needs of farmers, but encompassing the needs of environmentalists and researchers. The activities that redefined the programme purpose and workplans introduced a new style of interactive work, whereby farmers, environmentalists and researchers were advocating one anothers'work to those outside the programme. The way actors represented the programme to others fostered an emerging integrity that evolved from the work performed in the programme. This emerging integrity enabled the use of more sophisticated forms of reflection on action, whereby actors were judging and positioning the work of one another in the overall programme.

Part of the aspirations of policy-makers who advocated the reforms in NZ was to enhance the linkage between science and commercial institutions. This thesis did not set out to evaluate the reforms, so much as to identify new opportunities for collaboration in free market settings. Recommendations to actors and organisations, operating in free market contexts for innovation, are restricted to situations similar to the NZ dairy sector where a vertically integrated market channel is accompanied by sector programmes for young entrants to farming and coordinated information support services to farmers. Notwithstanding this qualification, it appears an appreciation of the way actors work together may assist programme managers in theatres of innovation and the management of technology. In particular, how these activities are coordinated and emerge as refined strategies for acting on problems and issues that are themselves emerging out of collective work. This thesis concludes that there is a need for further development of methodologies that can enhance analysts' abilities to observe activities in participatory working contexts. These methodologies ought to equip field analysts and programme managers who are grappling with contemporary issues of technology management in their conventional work.

Preface

This book was originally titled 'The Tragedy of Lonely Ideas', and was only changed to the current title 'Doing It Together'a few weeks before the work was completed. The tragedy was to refer to what the author considers a preoccupation with knowledge at a time when attention to the activities of actors is in need. The intent of the title was to convey the isolation that can occur when knowledge and actors dominate the strategy of organisations who are to serve, for example, the dairy sector. In selecting 'Doing it Together' the intent has been to emphasis the significance of activity in the building of linkages to manage technologies that meet the needs and aspirations of the actors involved in development programmes. The 'It' is therefore open to construction by the actors performing the work in programmes.

Note: Quotes from interviewees are in italics with names of individuals removed. Quoted from published material includes the names of individuals involved in the programmes discussed in the case studies.

Acknowledgements

The most pleasurable task for me comes at the end of the writing process - that of acknowledging those who have helped in diverse ways along the path to completion of this book. During the writing process I often recollected the saying, *'Of making many books there is no end, and much study wearies the body* (Eccles 12:12b.) The people mentioned below did much to reduce the burden implied in the above.

My wife Karenza has been a tower of strength and support through a period of tremendous strain on the family. Her practical wisdom inspires so much of my life that it is inevitable her influence has worked its way through in what follows. Our children, Lachlan and Fraser, have provided another form of inspiration as developing *'sense-makers'*.

Prof. Niels Röling has been unfailing in his enthusiasm for improving the lot of those who work with the land. Niel's openminded yet critical appraisal proved to be inspirational during a very demanding final phase of work to complete this thesis within the constraints of my NZ workplan. Perhaps the most enduring memory of Niels and his wife Prof. Janice Jiggins, will be their generosity and hospitality at dinner in their country 'retreat', solving the problems of the world over a good wine, as we fight off the chickens.

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A number of New Zealanders have also provided unfailing support. Dr. Gavin Sheath, my immediate employer, has given excellent criticism through the research and writing of this book. This criticism has been all the more valuable, as Gavin embodies much of what is called for from researchers who operate in free market situations. Prof. Robert Townsley has also contributed extensive personal and intellectual support for this work. I have considered Robert my mentor for a number of years, and always valued the debates we have had over the work in this thesis. Dr. Liz Wedderburn became a good friend throughout the work on the sustainability study group. Liz possesses an infectious enthusiasm for her work which made the action research aspect of this thesis a joy to perform. Dr. David McCall has been a friend for some years, and more recently a working partner. David possesses a rare combination of skills in mathematical modelling with a highly developed appreciation of farming systems that makes for very stimulating debates, though often on issues that extend beyond the farm gate - and agriculture!

The members of the extension research team in AgResearch have carried a considerable burden throughout the time required to complete this thesis. Terry Parminter, Annie Perkins, Lyn Hanes and Jenny Moore have all foregone personal opportunities because of my preoccupation with this work. Terry has been particularly active in attracting and servicing research contracts at a time when joint work would have greatly reduced the burden of delivery that was placed on his shoulders. Lyn was the remarkable individual who transcribed hours of audio tapes with considerable accuracy, given the often difficult recording conditions, and consequently poor sound quality, encountered in field settings. Ian Tarbotton, while not a member of the extension research team, has been a valuable colleague, particularly in the work on the sustainability study group. Ian's devotion to his work and commitment to the success of the programme was an inspiration to all participants. I am also grateful to the key informants and participants that permitted an 'outsider' to observe and discuss their programmes, often providing me with frank and penetrating comments.

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The contributions of all the people above, and others that I have failed to acknowledge, have made what could have been a *burden* into what was usually a very enjoyable experience. At the end of this work, though weary, I am equally excited about the possibilities and opportunities for contributing to the work of the New Zealand Dairy Sector because of the support received from these people.

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Abbreviations and Acronyms

AgR: AgResearch, New Zealand Pastoral Agriculture Research Institute Limited

AKS: Agricultural Knowledge System

BMSCC: Bulk Milk Somatic Cell Count

CBT: Controlled Breeding Technology

CIDR: Controlled Drug Release Device

CRI: Crown Research Institute

EU: European Union

FRST: Foundation for Research, Science and Technology

ICSCC: Inidividual Cow Somatic Cell Count

IPR: Intellectual Proprty Right

MAF: Ministry of Agriculture and Fisheries

MfE: Ministry for the Environment

MRST: Ministry of Research, Science and Technology

NMAC: National Mastitis Advisory Committee

NZDB: New Zealand Dairy Board

NZDE: New Zealand Dairy Exporter

PAR: Participatory Action research

PGSF: Public Good Science Fund

RMA: Resource Management Act

SAMM: Seasonal Approach to Managing Mastitis

SCC: Somatic Cell Count

SONZA: Situation and Outlook for New Zealand Agriculture - annual MAF report

SSGP: Sustainability Study Group

TBG: Technology for Business Growth

TDU: Technology Development Unit

ToT: Transfer of Technology

'Of course I do!' was what she said; *but 'I haven't the faintest idea'* was the message proclaimed by her voice and features which did not mould themselves to the shape of any recollection and by a smile that floated without support, in the air. (Proust, Cities of the Plain, Vol II, chp.1.)

Chapter One

Introduction:
Problems and opportunities for managing technology in New Zealand

The master fished with a line but not with a net; when shooting he did not aim at a resting bird. (Confucius The Analects: VII chp xxvi)

1.0 Introduction

1.1 Overview of Chapter One

The production of scientific knowledge has become a subject for policy debate in New Zealand (NZ). Societies like NZ are investing substantial sums in the production of scientific knowledge for a multitude of goals, though common to all is that the activity of creating knowledge is a fundamental attribute of being human[1]. Increasingly these societies are attempting to value ideas. Terms like *intellectual property rights* have become common place in western societies. Woven into the discourses that treat the creation of intellectual property rights as a function of social institutions like science and education are terms like *technology* that have for some time been common parlance. Recent economic reforms in NZ fostered extensive debates about the place of research, science and technology in society. These reforms, discussed in chapter three, achieved a rapid and dramatic reduction in public expenditure on the agricultural sector. For example, direct state subsidies to agriculture reduced from $1192 million in 1983 to $116 million in 1993 (Cloke, 1996). These reductions were achieved by privatising government extension services and withdrawing price

[1] For example, in NZ 0.8% of GDP will be invested in Public Good research, science and technology, to *'ensure investment in science as a component in national life which has cultural value in its own right; to foster in our society values and attitudes supportive of science and technology as critical to future prosperity; and to maximise the direct contribution of science and technology to wider social, economic and environmental goals.'* (MRST, 1995).

support schemes and fertiliser subsidies, along with other adjustments. Reforms also affected the NZ science organisations, referred to by policy-makers as the NZ science system (MRST[2], 1993). In essence central government was willing to invest in research, science and technology provided the sectors demonstrated a similar willingness to make investments to maintain competitive performance. The reforms therefore catalysed a need for improved linkage between science and commercial institutions. This need fostered debates about the concept of technology and the role of technology in improving linkages between the institutions of science and commerce. The work in this thesis was inspired by these debates that used technology as a means of linking science and commerce. What do we mean by technology, how do technologies evolve and can we improve the development and use of technology in future? The purpose of this thesis is to construct a perspective on technology that will assist those actors with strategic and operational responsibilities for developing and using technology towards internationally competitive performance by the NZ dairy sector.

This chapter will introduce the problem domain of knowledge and technology before outlining the contextual setting and research design for investigating this domain. The development and use of technology occurs in a social setting of actors who may compete or co-operate when performing their development or operational tasks. An appreciation of social issues relating to technology will need to consider the individual and collective work[3] of actors, and how these actors build a shared knowledge of their work. Uncertainty about appropriate social arrangements for actors to work together may result in potentially useful knowledge being neglected, or result in the performance of errors in work. How do actors organise themselves to work with others that share similar substantive knowledge and technology problems? Furthermore, working with others can raise a different class of uncertainties than those associated with the substantive concerns of the working partners. Uncertainties emerging from activities of working together are discussed in section 2.3 below.

In Section 3.0 the NZ setting is introduced as the context for investigating the problem domain. The discussion spans economic reforms that affected changes in the science system and the dairy sector. Section 4.0 introduces the research design and methodology used to perform empirical studies of technologies in the NZ dairy sector. This chapter concludes with central concepts developed and used throughout the text.

1.2 Organisation of chapters

An overview of the organisation of chapters in this text is provided in Figure 1.1. In chapter two a theoretical framework is assembled that will guide the reader through the subsequent case study analyses. This theoretical framework is accompanied by a contextual description in chapter three of the NZ setting for technology management in the NZ dairy sector.

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[2] MRST: Ministry of Research Science and Technology

[3] Work is used in a general sense to refer to the activities that actors perform, it does not necessarily imply a concern with issues relating to the division of labour, nor imply a Marxist perspective of praxis.

The case studies are found in chapters four through six. Chapter four investigates the design, development and use of a device for synchronising oestrus cycling in dairy cows. This case study involves an analysis of a situation where actors emphasise the hardware aspects of the technology. Chapter five is a case study analysing the emergence of a nation-wide mastitis management programme. Technology management in chapter five will emphasise social aspects of developing and using technology to lower the incidence of mastitis in the national herd. The final case study investigates events in a study group that is working on problems of resource management in a NZ dairy farming context. Actors in the study group emphasise cognitive aspects of technology as they seek to solve problems and learn in a complex and uncertain problem domain. The three case studies are analysed individually before a cross case analysis in chapter seven. The quest in this final chapter is to identify a common perspective that can explain the events in each case study in a way that informs technology managers operating in a free market economy like the NZ dairy sector. What are the types of problems currently confronting those actors working with new technology in the current NZ context?

2.0 Problem Domain

2.1 Scientific knowledge and technology

New policy under the reforms has continually grappled with problems of clarity about what policy-makers, the public, and actors in the productive sectors refer to when they use terms like science and technology (Ministerial Working Party on Research, Science and Technology, 1991; Clark, 1992; MRST, 1995). This problem domain is not so much about the search for ever more correct definitions of these elusive concepts. A more serious concern is an assumption that the use of these terms in policies, and in cultural and productive activities is consistent one with the other. For example, a recent strategy document from MRST (1995, p.10) claimed:

> *'Throughout this document, as emphasised by the definitions given above, the world view providing a broader context for the strategy is one which reflects an internationally accepted view of science. This approach is evidently trans-cultural, since science, as described above, is very much a global endeavour with agreed methodologies and international peer-groups.'*

If policy is designed and conditions established for actors in the sectors to perform *assuming* (as in the quote above) a consensus about the nature of science and technology, then it is possible that conceptual inadequacies in deterministic definitions will undermine the very outcomes sought by strategy. Furthermore, the document is inconsistent, in that the vision[4] to build science values belies the existence of a shared worldview. Why aim to foster universal understanding and values for science and technology if a worldview of science and technology already exists? This problem of ambiguity is accentuated under free market reforms, which

[4] Specifically (p.11), *'The vision for research, science and technology in NZ to the year 2010 is a society which understands and values science and technology, and their role in assuring NZ's future prosperity and well-being, and maximises the contribution of science and technology to wider economic, social and environmental goals through scientific research and technological innovation of the highest quality.'*

emphasise the attainment of pragmatic outcomes. Actors working in a marketing channel, seeking to supply quality products to international markets, are unlikely to concern themselves with the adequacy or otherwise of terms used for science and technology. Yet these same actors in the marketing channels are likely to be some of the most significant figures determining the fate of science and technology operating in their sectors.

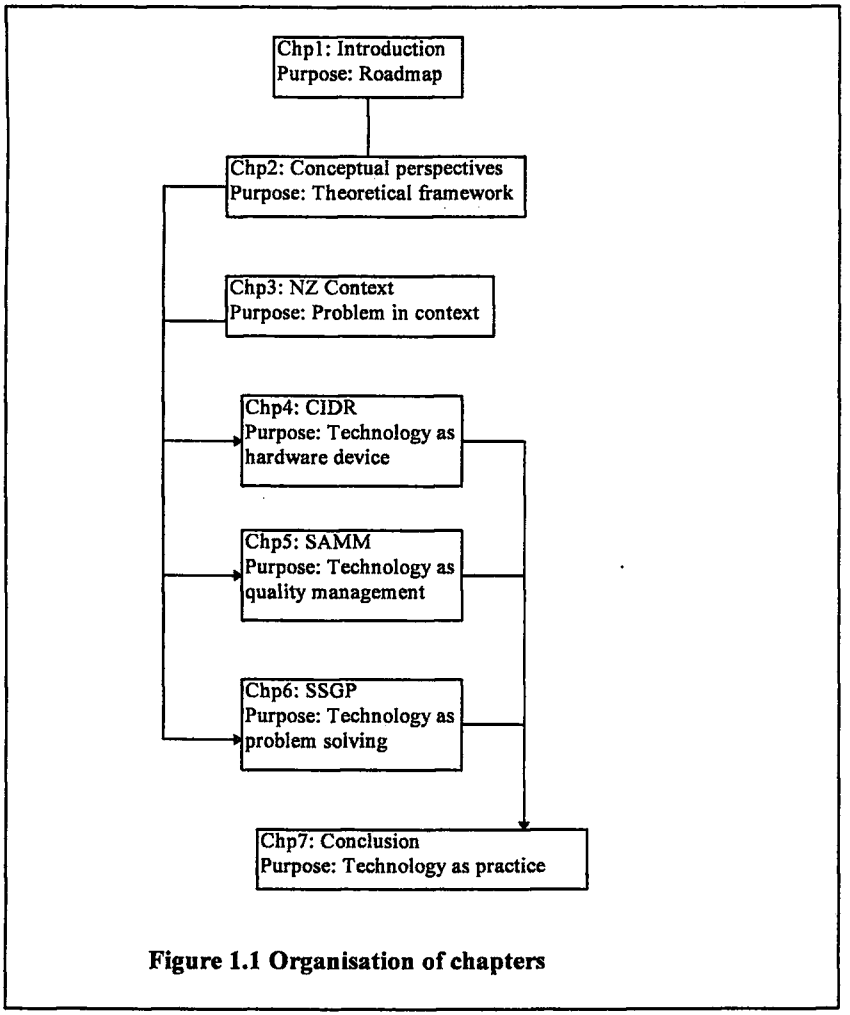

Figure 1.1 Organisation of chapters

These problems of definition and action relating to science and technology values are the subject of chapters two and three. In these chapters the problem domain is appreciated as more than a short term difficulty for those actors working in science

professions[5] to justify their existence on the basis of technological outcomes offered to shrewd actors working in commerce. To the contrary, the problem develops towards an appreciation of what makes for improved working relationships between research and commercial activities. That MRST was active in the definition of technology operating in a free market science system provided an opportunity to contribute towards innovations in policy. In particular, to develop a perspective of technology management that deals adequately with issues of human activity when new technology is involved in those activities. Resolving how an understanding of technology is worked out among actors in science and commerce ought to assist those actors who are concerned with designing new policy for research, science and technology.

2.2 Working with others

It follows from the above that the nature of the relationship between science and commerce in terms of developing and using technology is problematic. Furthermore, the reforms mentioned in Section 1.0 established new conditions for the way actors operate in the areas of science and technology. An investigation of technology in the NZ dairy sector therefore needs to appreciate structural and functional[6] issues that influence the development and use of technology spanning both science and commerce institutions. However a description of the conditions under which actors operate will fail to disclose the way these actors in some way exert influence and construct their world of work. A study of technology management will require some way of appreciating the technological world of work within which each actor operates.

An investigation of people working together requires clarification of the general perspective used by the analyst who is observing the social interactions. The case studies in this thesis have been informed by a symbolic interactionist position that guided theoretical and methodological developments. Symbolic interaction focuses on the way meaning emerges from the interactions among actors. How this focus is performed is described in Section 4.0 below. A tenet[7] of symbolic interactionism is that the social world is interactive - that 'no man is an island unto himself' - and constructed by the actors who form part of their social world. The worldview in this thesis holds that there is a reality, but that each actor constructs symbolic representations to make sense of that reality - a universally constructed reality is probably unattainable in life as we know it. From this perspective the problem of people as actors is that confusion, ambiguity and conflict is at least as likely to occur as a unity of effort towards building a shared future.

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[5] Note: the term profession is not to be confused with practice (developed later in this text), as a profession may perform more than one practice.

[6] Structure here refers to organisational and institutional arrangements in sectors, function refers to the dynamic flows of resources in these arrangements.

[7] The four tenets of symbolic interactionism are:

1. Actors are symbol manipulating animals
2. The social world is a dynamic and dialectical web or uncertainty
3. The social world is interactive
4. To investigate the social world, the analyst must look beneath the symbols and interactions to identify the underlying patterns of social life. (From Marshall, 1994).

In a free market, freedom may mean opportunity for creative alignment, or creative anarchy. In approaching problems relating to human interaction some clarity is required in the analysis of actors and their actions. Analyses may emphasise the knowledge based attributes of actors, or conversely focus on the activity attributes of actors. Typically most studies of human interaction appreciate both dimensions and clarification is more a matter of the relative emphasis placed on the analysis of activities and actor cognitions in relation to emerging technologies. This methodological consideration is developed further in section 4.0 below.

The analytical and strategic implications for organisations who provide and use technologies in the dairy sector will emerge in each of the case studies and are combined in the final chapter.

2.3 Uncertainty

The problem domains discussed above are subsumed by a more general problem of uncertainty. The problem of uncertainty has been a central concern among some economists throughout this century (Wubben, 1993). As mentioned above, uncertainty is also a domain of interest to social researchers. Economic analyses have considered uncertainty in situations where more than one possible outcome may emerge from a particular course of action. Social analyses are concerned with the uncertainty of the very actions that may give rise to more than one outcome - the human disposition is uncertain. Under the reforms, following policy that was itself informed by a class of economic theory relating to uncertainty, the problem domain of technology has two dimensions. A concrete dimension of substantive technical problems and a social dimension of actors and their relationships.

Farmers, processors and marketers use technology to reduce the uncertainty surrounding the performance of farming, processing and market activities towards competitive sector performance. Furthermore, interventions are used by those who provide technical information to farmers, processors and marketers to reduce the uncertainty of human performance in the context of a marketing channel. This thesis is particularly concerned with this second dimension of uncertainty and the use of interventions in sector programmes. Interventions are concerned with the ways that actors learn and adapt to changing circumstances. This research will seek to assist those actors who co-ordinate sector learning programmes, providing a strategic framework for managing under uncertainty.

Problem Statement

The foregoing discussion identified technology as a central concern to policy makers who sought to improve linkages between the institutions of science and commerce. The problems and issues confronting these actors in the NZ science system have generated problems for researchers who are focused on the study of innovation. Questions relating to the nature of technology have emerged, viz.:

- is it adequate in a free market context to use a perspective that emphasises the knowledge attributes of technology?

- does technology mediate the relationship between these institutions, or is technology an outcome of some other linkage mechanism?

To direct the research in this thesis these questions have been formulated into problem statements that focus on a substantive sector (dairying) at the conclusion of chapter three as follows:

1. How do organisations and actors link their activities to evolve technology for use in the NZ dairy sector?
2. How can an understanding of these linkage activities inform technology managers in a dairy theatre of innovation?

3.0 The Context of the Problem Domain

Chapter three provides a contextual backdrop to the analysis of technology management in the NZ dairy sector. This context is organised with respect to changes in economic policies, description of the NZ dairy sector and organisation of the NZ science system. The problem statement emerges as a combination of this context with the development of concepts relating to technology management in chapter two.

3.1 Economic reforms in NZ

A series of economic reforms were introduced in the mid 1980's to correct a failing national economy. These reforms are described in terms of the historic significance of farming sector activities in the economy, and the conditions that led to an undermining of economic stability in NZ. The rationale for adopting a free market model for the reforms is described before describing the impact of these reforms on agricultural sectors. Chapter three does not set out to critique the economic reforms, but refers to the reforms in terms of emerging conditions that influenced the management of agricultural technology in the NZ dairy sector.

3.2 The dairy sector

A second contextual description outlines features of the dairy sector pertinent to the development and use of technology. This description opens with an historical overview of landuse in NZ and the emergence of pasture based farming systems. A series of technological innovations are associated with significant development phases in the history of NZ pasture farming. The changes in the ownership structure and work force operating the pasture based production system used for dairy farming in NZ are described before presenting general statistics on the size and performance of NZ farms. Discussion then moves to the vertically integrated arrangement of organisations to perform according to the requirements of an export marketing channel. An enduring sector goal is to remain internationally competitive by operating as a low cost producer of milk. This goal is discussed before describing the role of agricultural research and development (R&D) towards its achievement. Sector R&D activities are introduced with respect to organisational arrangements that seek to align R&D

outcomes with sector needs. This overview concludes with a series of contemporary on and off-farm challenges confronting the sector. Many of the features of the dairy sector are not common to other sectors in NZ agriculture. The reasons for using the dairy sector in this study are described with a proviso clarifying that the findings may not be immediately transferable to other sectors.

3.3 A new science system

The reforms instigated a restructuring and realignment of NZ science organisations, referred to by policy-makers as the NZ science system (MRST, 1993). Chapter three describes the rationale, organisational changes and new expectations that reformers had of these organisations. An ongoing problem in the reforms was the need for improved linkage between science and commercial institutions. This problem has had most impact on the workers in research organisations. Furthermore, improved linkage with the productive sectors was demanded at a time when some of the extension faculties of the research organisations were dismantled under the reforms.

A general problem statement is developed around the issue of linkage between science and commercial institutions. It is acknowledged in the development of the problem statement that some sector organisational arrangements may help alleviate problems of linkage, however it is argued structural arrangements are insufficient in themselves to resolve problems of alignment. The chapter concludes it is necessary to investigate the emergence of working relationships within contemporary programmes that develop and use technology in the dairy sector as a first step to understanding problems of technology management.

The following section describes the methodology used to investigate the problem of emerging relationships in programmes for developing and using technology in the dairy sector.

4.0 Overview of Approach

4.1 Research Design

The research design used in this study selected the dairy sector as a means of improving the ability to observe programmes that to some extent succeed in building effectively towards the use of technologies in competitive sector strategies. Structural arrangements combined with access to information and track-record with workers in the sector reduced problems of access for the researcher. Current programmes that span science and commercial institutions were further reasons for using the dairy sector as the context for the case studies.

The programmes selected for case study analysis within the dairy sector attempted to cover a range of technological settings. Three programmes were selected for their emphasis on technological aspects like hardware, or cognitive attributes, and for the intervention perspective with which they align (see Figure 1.2). An intervention

perspective is the way that policy or sector leadership frames activity and understanding towards improving the development and use of technology to achieve sector goals. Three common intervention perspectives include:

- Transfer of technology: technology is depicted as a development emerging primarily from scientific endeavours that is then *transferred* to users in productive sectors.
- Knowledge systems: technology is depicted primarily in terms of knowledge attributes that derive from negotiative processes operating among organisations arranged in systemic configurations;
- Participatory action research: users are involved in the development processes responsible for the emergence of technology - action research refers to the researchers acting as participants, with the users, in the development process.

This selection of programmes provided diverse and comparative research contexts to investigate technology. The case named CIDR is discussed in chapter four, being a tangible technical device that has a clearly defined and specific application in the NZ dairy farm system. The development history was known and considered a success by developers, users and funders of the technology prior to the case analysis. The researcher did not influence technology management outcomes in this *ex post* analysis. The intellectual property that emerged during the development of this technology was clearly specified and a significant issue to the actors in the case.

In contrast to the CIDR case, the SAMM did not involve any one specific device, but used a number of devices and tools to address a multi-faceted problem. The development history and outcomes were largely known when the case analysis began, though the researcher became an active research participant in issues pertaining to the programme in the latter course of events discussed in chapter five. Intellectual property was not a significant issue in the programme, being a sector-wide initiative, but in the subsequent history of the programme property rights were secured by some actors over aspects of the programme.

The final programme, discussed in chapter six, focused on a highly complex issue and commenced with an obscure problem definition relative to the previous programmes. The outcomes of technology management activities in the programme were unknowns at the start of the case analysis. The researcher was an active participant in the programme. Intellectual property was a comparatively insignificant issue compared with previous programmes.

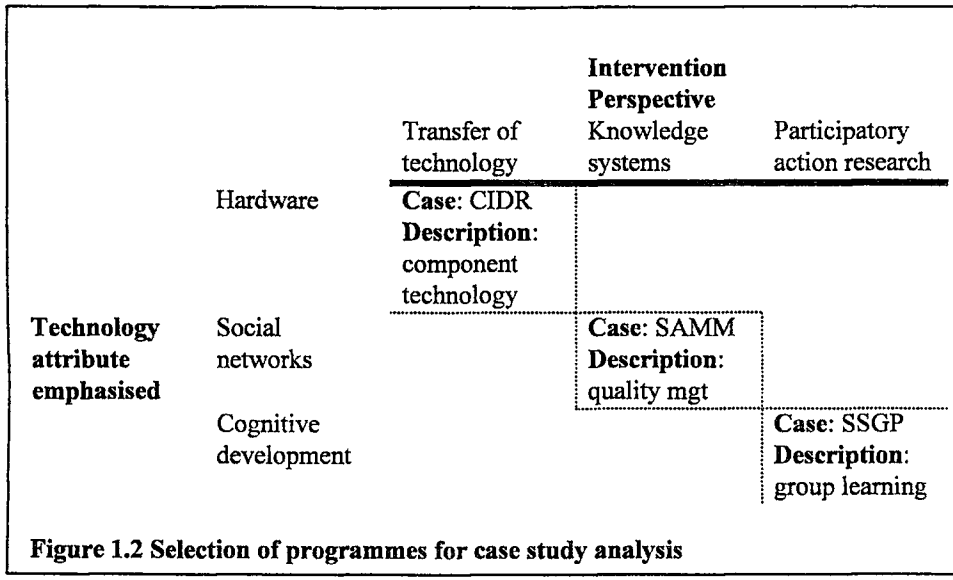

Figure 1.2 Selection of programmes for case study analysis

Yin (1994) provided this thesis research with a useful start point to frame the case study research strategy. To Yin, a case study is

> *'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomena and context are not clearly evident. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulated fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis.'* (ibid., p13)

Case study research is the preferred approach to investigate events over which the researcher has little or no control. The approach has been criticised for a lack of scientific rigour, particularly the prevalence of equivocal evidence and biased views in research reports. Some critics claim case studies provide little basis for scientific generalisation and are not sufficiently parsimonious to be valued as quality items of science. Cases studies can be defended against these criticisms when all evidence is fairly reported, and a grasp of the research logic is shared by researchers and their audience. Case study evidence is analytically generalisable to theoretical propositions. An appropriately developed theory identifies the level at which the generalisation of results will occur. Previously developed theory provides the template for comparing empirical results of the case study, if two or more cases support the theory then replication can be claimed. The results are even more potent if two or more cases support the same theory, but do not support an equally plausible rival theory. This perspective of case study research is more aligned with experimental generalisation than statistical generalisation. Case studies do not depend on the correlation techniques of statistical generalisation, which makes inferences using data from a sample representing a population.

Yin (1994) describes the experiment as a divorcing of phenomena from context, by controlling for a few variables using a laboratory environment. He refers to case studies as neither a data collection technique, nor a design feature, but a comprehensive research strategy - the logic of design incorporating specific approaches to data collection and analysis. As such, case studies have been used in research to explain the outcomes of real life interventions that are too complex for survey or experimental strategies. Yin used an analysis of the Watergate affair as an example of a case study investigation that determined how and why the cover-up occurred - a piecing together of fact after fact to systematically build a comprehensive explanation of a complex human situation.

Several criteria can benefit a research design process involving case studies. Case studies derive construct validity - establishing the correct operational measures for the concepts being studies - by using multiple sources of evidence and participatory research methods. The participation of key informants can also improve the internal validity of case studies, building explanations of relationships in contemporary situations inaccessible to the independent researcher. Difficulties in establishing the external validity of case studies can be resolved by testing theory through replication logic, similar to that underpinning experimentation logic, to establish the domain to which findings can be generalised. The theory defines the general population and situations to which case study findings are extrapolated.

Yin was particularly concerned with the use of the case study research to explain social phenomena. The concern of intervention studies goes beyond explanation to effect a change in social settings - change management. Gummesson (1988) was critical of Yin's (1984) preoccupation with the testing of theory, arguing that the use of case study research to generate theory was a more significant outcome in change management situations. Gummesson's contention was that action research was the most challenging but useful case study approach for change management.

Argyris *et.al.* (1985) distinguished social research methodology by the relative emphasis placed on the explanation of social phenomena or problem-solving. Normal science is primarily explanatory. Argyris referred to action research as a class of methodologies that are capable of informing interventions while contributing to theories of action. Both methodological orientations attempt to explicate the processes responsible for the observable phenomena.

Participatory action research (PAR), is a particular type of action research that involves practitioners[8] in all phases of the research process (Foote-Whyte, 1991). In an ideal PAR situation the practitioners under study actively participate with the researcher in all stages of the research process. More typically the researcher initiates the project, facilitates meetings, assists with data collection and plays a major role in the analysis of results. The researcher is usually responsible for presenting the study findings, while the practitioners undertake to implement recommendations. Practitioners and researchers share the tasks of formulating problem statements, specifying the variables and selection the methods of data collection, analysis and

[8] actors who perform in a substantive domain of action.

interpretation. PAR emphasises intervention as a mutual learning process shared by researcher and practitioners.

The level of practitioner participation deemed desirable by PAR proponents is often infeasible in many social research projects. Constraints of time, funding and skills often call for compromises to initial design proposals. In particular, leadership skills are often a significant consideration in PAR designs. The leadership of a programme is a distinguishing feature of the case:

> *'For building effective participatory systems, whether in industry, agriculture, or research projects, the requirements for leadership are quite different from those traditionally expected of a leader in a hierarchically designed organisation. The leader should be able to project a vision of the organisation's mission, with broad potential appeal to members, and then guide and facilitate the changes necessary to advance toward that vision. In participatory action research, this means that the researcher must be willing to relinquish the unilateral control that the professional researcher has traditionally maintained over the research process. This does not mean that the professional researcher must accept every idea put forward by key practitioner collaborators. It does mean that the researcher must rely upon rational discourse and powers of persuasion in planning and implementing PAR projects that meet the needs and interests of both research professionals and our collaborating practitioners.'* (Whyte, 1991, p241).

The programmes selected in this study varied in their emphasis on PAR, from the CIDR (least participatory) to SSGP (most participatory).

Southwold and van Dusseldorp (1994) discussed the role of PAR in social research for rural development. Their analysis related to experiences with village level studies in developing countries, yet many of their general observations are particularly informative with respect to the SSGP case study, forewarning of potential advantages and disadvantages of using a PAR design.

Advantages

The primary advantage of using PAR is that practitioners collect and analyse data in the context in which they work. In a sense they access information that would otherwise be inaccessible to an independent researcher, because practitioners have first hand experience of their problems in a working situation. The research process accesses the experience and expertise of these practitioners. Participation is crucial if practitioners are expected to commit scarce resources to perform in programmes. Interventions have a higher chance of being sustained by the practitioners when they share some form of identity with the programme. Participatory research facilitates the organisation of practitioners to take collective action. Emphasis on action and participation is an appropriate first step in strategy. Practitioners' values are made explicit to avoid constraints to effective dialogue. In summary, PAR improves the capacity of practitioners to solve their own problems by providing insights to processes operating in their environment, and stimulating the mobilisation of collective action.

Disadvantages

Critics of PAR argue that participatory designs lack the objectivity attainable in normal social science designs. The contention that research is value-free has received

widespread criticism in recent years (Feyerabend, 1991; Lynn, 1987; Pickering, 1992; Vietor and Cralle, 1992; Ziman, 1978). Participatory research work derives validity by practitioners involvement in active critiquing of propositions and interpretations, imparting a high level of internal validity to the research results. The external validity of PAR depends on the link made between theory and the analysis of case material. The success of PAR designs is heavily dependent on a facilitation process to motivate practitioners and enlist their commitment to the research process. Facilitation in turn is dependent on the personal qualities of the facilitator which demands comprehensive documentation of interventions to secure evidence for the "repeatability" of group processes. Facilitators can easily manipulate practitioners to gain commitment to projects in the short term, yet engender long term resentments against the facilitator and the institution (s)he represents. Other unforeseen conflicts can also arise when PAR delves into perceived patterns of social process that awaken an aggressive or defensive stance among some practitioners. Special negotiation skills of the facilitator are required when conflict emerges in PAR situations (Argyris and Schon, 1991). These conflicts can fuel political tensions among institutions if left unresolved.

The development of theory is a critical aspect of the research and intervention process.

> *'It is not merely a question of temporal priority but rather one of function of "research" (theory building and testing) within and in relation to "action" (organisational intervention). On one view, organisational intervention is said to be suggestive or evocative of theoretical insights. On the second, it is said to have a distinctive function as a context for theory building and a means of theory testing.'*(Argyris and Schon, 1991, p92).

The case study is a particularly powerful means of generating and modifying theory. Mitchell (1983) defines the case as:

> *'the documentation of some particular phenomena or set of events which has been assembled with the explicit end in view of drawing theoretical conclusions from it'* (p191)

Inferences are made on the validity of the case rather than the representativeness of events. Cases preserve the unitary character of the social object being observed. Extended cases (Mitchell refers to these as complex cases) deal with a sequence of events over time with the same objects involved in a series of situations forcing the continual respecification of theory. The building of theory from empirical evidence using a case study research strategy has received considerable refinement in the grounded theory methodology (Glaser and Strauss, 1967). The following section discusses how grounded theory was used in this study.

4.2 Methodology

The following discussion of methodology provides an extensive introduction to Grounded theory as developed by Barney Glaser and Anslem Strauss. This discussion was considered necessary because of the significant and unique attributes of the methodology for the development of theoretical perspectives in this thesis. Grounded Theory was initially developed as a way to make progress on the study of dying patients (Glaser and Strauss, 1964; 1967). Their methodology builds theory using a

systematic procedure for collecting and coding data. This procedure, referred to as the constant comparative method, uses data gathered in a variety of forms such as field notes, transcripts, videos, secondary data. These data are gathered using interviews, focus groups and/or participant observation techniques. The feature of grounded theory that distinguishes it from most other forms of social research is the way the methodology **builds** theory inductively, rather than **tests** a theory that derives from deductive principles.

> *'Grounded theory is based on the systematic generating of theory from data, that itself is systematically obtained from social research. Thus the grounded theory method offers a rigorous, orderly guide to theory development that at each stage is closely integrated with a methodology of social research. Generating theory and doing social research are two parts of the same process. How the analyst enters the field to collect the data, his method of collection and codification of the data, his integrating of the categories, generating memos, and constructing theory - the full continuum of both the processes of generating theory and of social research - are **all** guided and integrated by the **emerging** theory.'* (Glaser, 1967, p.2)

The methodology begins with open questioning of events in the data, then progresses to more selective questioning, to eventually form conceptual linkages among coded items in the substantive domain of interest. A continuous searching and returning to the original data begins to evolve a theory (see Figure 1.3). Repetitive comparisons between proposed linkages among events *grounds* the emerging theoretical framework. This framework underpins subsequent efforts to generate hypotheses relating to the substantive domain. Hypotheses are usually tested in follow-up studies using quantitative techniques (Glaser, 1992).

The combination of questioning and comparing of events motivates the researcher to search for additional data.

> *'The logic of grounded theory as stated most clearly in Theoretical Sensitivity is to ask two formal - not preconceived - questions. They are: What is the chief concern or problem of the people in the substantive area, and what accounts for most of the variation in processing the problem? And secondly, what category or what property of what category does this incident indicate? One asks these two while constantly comparing incident to incident, and coding and analysing. Soon categories and their properties emerge which fit and work and are of relevance to the processing of the problem.'* (Glaser, 1992, p.4)

The search for additional explanatory data is referred to as *theoretical sampling*. The analyst is *sensitised* to the need for additional data because the inadequacies in the current data to explain the substantive problem. By recognising the limitations of the currently available data, the analyst is sensitised to seek out, for example, a key informant or locate a secondary data source inspired by a question that emerged during the coding process. *Coding* refers to the way descriptive data of events (e.g. video footage) are questioned and compared for similarities and differences with other data to build towards a general term (category) that covers many events. Often the properties of a category are *discovered* by the analyst before the category itself is immediately obvious.

The analysts task is to seek out that category that explains most variation in the social phenomena observed - this being the *core category*. As data accumulates towards filling gaps in the explanation of the substantive problem, a point of theoretical

saturation occurs - diminishing returns from each successive effort to gather data has expended the need for gathering additional data relative to the holistic emergence of the theory. This inductive coding process is accompanied by a deductive process that uses *memos* to record and stores concepts that are inspired by the coding of concrete events. A theory emerges that is *grounded*, because memos have direct link to codes and concrete events that inspired their construction. Two types of memos are recorded by the analyst: theoretical memos that are directly related to the emergent theory; and methodological memos that record concepts and ideas for improving the research process. Grounded theory enables the analyst to systematically reflect on the actions of others (theoretical memos) **and** systematically reflect on actions as a researcher (methodological memos).

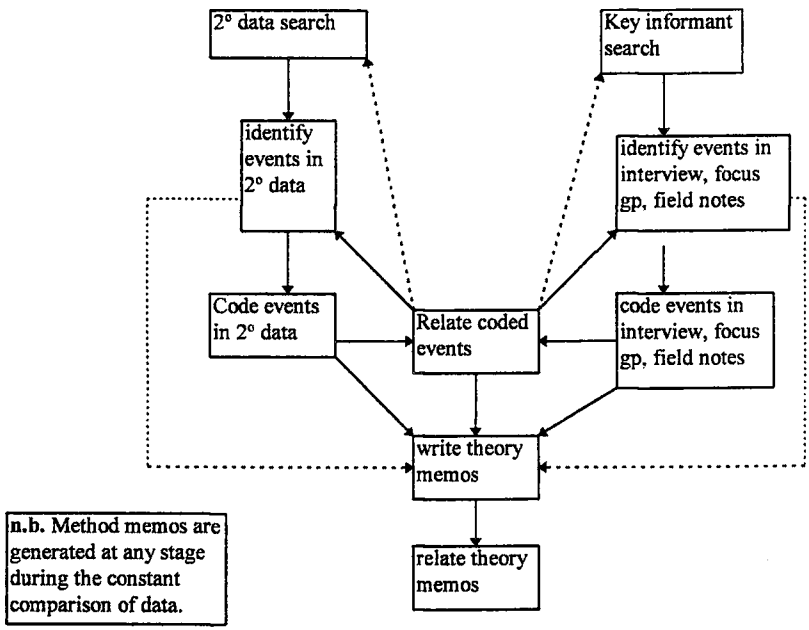

Figure 1.3 Constant Comparative method used in Grounded Theory

A simple dairy farming example serves to illustrate the use of grounded theory and to identify the significance of the methodology for this study. The analyst may observe the movement of stock to and from the milking shed, morning and evening, as a regular pattern in the seasonal work of the farmer. As event is compared with event and the questions emerge, the analyst notices variations in the general pattern. For example, stock move to and from different paddocks, and the length of time spent on each paddock varies through the season. At times the herd is divided into separate smaller herds. The analyst may question different aspects of pasture management.

animal health and milking procedures to build a *category* termed stock rotation policy that has several dynamic *properties* like pasture growth rates and pasture quality. This category may also be *connected* with other emergent categories like milk harvesting by connecting the properties of milk yield (milk harvesting) and pasture quality (rotation). This example assumes the analyst has sufficient *access* to observe the requisite dairy farming events. The provision of adequate access to critical events is not often discussed in grounded theory literature (Gummesson, 1988). Gummesson argues that that when the analyst is also the change agent, the problem of access is minimised. Furthermore, the example does not specify the analyst's prior knowledge of the farm system. Gummesson uses the term *preunderstanding* to refer to this issue of the analyst's prior knowledge of a situation under investigation.

Preunderstanding is acquired through a combination of experience in the domain of work and through formal information such as models and documented experiments. An analyst's preunderstanding is somewhat like a two edged sword to the research endeavour, as extensive preunderstanding may assist with rapid identification of the problem and development of theory using many preconceived assumptions that are not grounded in data. Conversely, the naive researcher may rapidly close down opportunities for access to critical events if the questioning process frustrates key informants through a failure to rapidly grasp crucial concepts involved in the problem domain. Use of the constant comparative method ensures the experienced analyst is continually anchoring concepts in concrete events. The naive analyst requires considerable questioning and listening skills to counter lack of familiarity with the problem domain. In this study the analyst had extensive prior experience (15 years) in working with farmers and consultants, though only two of these years were involved with dairy farmers.

Grounded theory methodology is particularly suited to action research that involves change management situations. Glaser (1992) advises analysts to keep the methodological rules to a minimum in the interests of developing useful theory:

> *'In fact, grounded theory is difficult enough just following the direct simple rules we wrote in previous books, principally the constant comparative method. Too many rules get in the way; they block emergence. The grounded theorist should simply constantly code and analyse categories and properties with theoretical codes which will emerge and generate their complex theory of a complex world! And in turn they will produce simple or complex explanations along the way of the processing of the concerns of a substantive area. The key phrase is to* ***just do it!*** *'*(p.71)

In the quote above Glaser was responding to a rift that had developed between himself and Strauss over the development of grounded theory. Throughout the 1980's a vast literature had emerged in social studies of medical and management professions (see for example Glaser, 1993; 1994; 1995). However, the publication of *Basics of Qualitative Analysis: grounded theory procedures and techniques* (Strauss and Corbin, 1990) prompted an acerbic reaction from Glaser (1992). Glaser accused Strauss of refining conceptual description by forcing data to fit preconceived theoretical categories:

> *I have tried to show the slow transition by Strauss from a grounded theory we both developed, to his development of a verificational method which forces the deducting and testing of preconceptions in the service of full conceptual description.* (Ibid., p.89)

Stern (1994) referred to this divergence in Glaserian and Straussian methodologies as an eroding of grounded theory. In her view it has become important for the analyst to make clear which methodological school they are operating from:

> *'The crux of the dichotomy is, I think, that Strauss, as he examines data, stops at each word to ask, "what if?" Glaser keeps his attention focused on the data and asks, "What do we have here?" Strauss brings to bear every possible contingency that could relate to the data, whether it appears in the data or not. Glaser focuses his attention on the data to allow the data to tell their own story.'* (Ibid., p60).

A Glaserian approach to Grounded Theory was adopted in this study, placing emphasis on the emergence of theory rather than verification and testing of a preconceived theoretical position. This claim may seem at odds with the arrangement of the book. A conceptual framework is offered in chapter two, followed by a series of case studies, with chapter seven reworking concepts initially introduced in chapter two. This arrangement is designed to provide the reader with a logical development of perspectives on technology management. However, the construction of chapter two emerged as an iterative process whereby emergent categories sensitised the analyst to theoretical perspectives. A perspective of technology management operating in a free market science system therefore emerged out the case study research and was located in relation to existing theory. Section 4.3 outlines how the schedule of events unfolded in this grounded theory exercise towards the emergence of theory. Fieldwork and scholarship combined over time, though a general research design was prepared prior to entering the field (see Figure 1.4.)

The constant comparative method helps the analyst to organise a rapidly accumulating store of data as each case study unfolds. Furthermore, recent software developments have further enhanced the analyst's ability to rapidly store, recall, (re)code and electronically make memos of recorded data. This study used the Qualitative Solutions and Research (QSR) NUDIST (rev. 3.0) software package to manage data. NUDIST is an acronym for Non-numerical Unstructured Data Indexing Searching and Theorising (Richards and Richards, 1993). The software enabled the coding of on-line documents like transcripts and fieldnotes, and off-line documents like annual reports and science papers. The coding process builds a tree structure of parent and sibling node addresses (see Appendix One).

Each node address references the on-line and off-line data that was originally coded to the node. Fieldnotes, dictaphone recordings of interviews, focus groups and field discussion groups were transcribed and entered as separate on-line documents into a separate NUDIST file for each case study. Each document was then analysed as text units, being those segments of transcript that are allocated to node addresses. The analyst can build memos for each node. A node definition and description can be changed at any time, as can the location of the node in the tree structure. The analytical power of the software is the maintenance of codes and memos, linked directly to primary and secondary data, while the analyst continues to add data following theoretical sampling procedures. Furthermore, codes can be readily modified and new tree structures trialled as the theoretical perspective emerges. NUDIST contains a number of search routines that enabled single and multi-node searches of on-line data. These routine search operators can be further complemented by the analysts personalised command files. A command file enables the analyst to

manipulate tree structures, coding, filing and reporting procedures (see Appendix Three). Specific NUDIST details for each case study are appended (see Appendix One). Furthermore, the reporting format for each case study is consistent with Grounded Theory. Substantive events are introduced and analysed in terms of critical issues before discussing the emergent issues that can be learnt from the events.

The mentoring process is critical in the development of Grounded Theory analyses (Glaser, pers. comm. May 1996). Mentoring in this study was gained through several sources. Initial experience with Grounded Theory was gained in course work and informal discussions with colleagues during the research design stage at Wageningen Agricultural University. On returning to NZ informal links with other grounded theorists culminated in a three day workshop with Barney Glaser and the subsequent formation of an electronic network shared by course participants. Furthermore, this analyst was a participant in a local seminar group that was organised to critique the work of group members. The seminar group met fortnightly during 1996 to critique one another's case study reports and papers, and share articles considered pertinent to the work of the group. The QSR organisation provided an international electronic network (listserver) that linking those researchers who were using NUDIST to exchange experiences with the programme and foster new innovations in research applications.

4.3 Significant events during the performance of this study

The schedule of research activities is performed in this study is summarised in Figure 1.4.

Year	Quarter	General	Case Studies: Theoretical sampling	Case Studies: code + memo	Case Studies: Concept + writing
1994	1	Literature review			
	2	Research design			
	3	↓			
	4	Literature review			
1995	1	Fieldwork preparation			
	2	Literature review	CIDR; SSGP	CIDR; SSGP	
	3	|	↓	|	CIDR; SSGP
	4	|	SSGP;SAMM	↓	↓
1996	1	|	↓	SSGP;SAMM	SSGP;SAMM
	2	↓	SSGP	|	|
	3	Writing up		↓	↓
	4	|			
1997		↓			

Figure 1.4 Schedule of research activities

Fieldwork commenced in 1995 on the CIDR and the SSGP, the latter being a participatory programme that required an extensive period in the field with participants in the programme. Completion of CIDR case analyses enabled fieldwork to begin on SAMM in late 1995, extending through 1996. Literature reviews continued, with less emphasis than in 1994, throughout 1995 until the middle of 1996 when the writing of chapters dominated research activities. Draft write-ups of each case study were sent to key informants for their comments and criticisms before writing the final versions.

5.0 Central Concepts

A number of terms and concepts are developed in subsequent chapters that may be either new or used in ways unfamiliar to some readers. This section is included to reduce the burden of navigating through the following pages. Furthermore, a glossary has been appended to help with clarification of terms. There are five central concepts to this thesis that are developed below. These concepts recur throughout the remainder of the text and are emphasised here to alert the reader to their development and use in the case studies and in the emergence of theory.

Technology

This chapter started with a brief discussion of how technology was used to link science and commerce in the NZ science system that emerged following economic reforms. Technology was defined by MRST (1995) as:

> *'know-how or practical knowledge which is directly able to create improved and/or cost-effective products, processes and systems. Know-how might be attained through the application of science, but might equally be attained through trial and error, cumulative practical experience, or a combination of all of these. Although science and technology are not necessarily linked at any point in time, technology is increasingly becoming science based and its usefulness can be extended and enhanced if its scientific basis is understood. Conversely, the process of technological innovation can yield questions which ultimately give rise to fundamental advances in scientific knowledge.'* (p.10)

Two attributes of technology are emphasised in the above definition: technology is a type of knowledge; technology and science are different but can be managed in such a way as to be complementary. According to this definition it is knowledge that creates improvements in *'products, processes and systems'*. However, this emphasis on knowledge does not account for the actions that are performed to generate products or processes. This thesis aims to develop an adequate notion of the actions of actors with respect to the development and use of technology. In referring to actions, a second concept emerges - that of practice.

Practice

The concept of practice will be developed in chapter two as referring to the way actors perform their work - a practice is a way of doing. The relationship between technology and practice is explored in the case studies and further developed in chapter seven. A practice perspective therefore focuses on the actions of actors. The

emergence of a practice perspective will provide an action rejoinder to the knowledge perspective of technology currently emphasised in the NZ science system. In a practice perspective of technology, knowledge is socially constructed as a consequence of reflecting on actions. A practice is the generally accepted and shared, habitual, taken-for-granted way of doing, understanding, communicating and co-operating - it constitutes the new recruits basic question - 'how are things done around here?' A practice includes arrangements, methods, procedures, schemes, and techniques for coping and accomplishing outcomes in response to problems. The performance of a practice by actors is intentional. This intentionality introduces a third concept - strategy.

Strategy

The term strategy, like technology, has gained recent popularity accompanying the expansion of business management education in western societies. Strategy was originally used in a military context to refer to the 'art of war', or the management of an army in a campaign. Common use refers more to the intentionality embodied in activities performed by actors in a world of uncertainty. Strategy in relation to technology is introduced in chapter two, developed through the case studies, and later applied to problems of uncertainty in chapter seven. The orientations of strategy can be competitive and/or collaborative. Notwithstanding the significance of competitive strategy in relation to managing technology, this study seeks to contribute developments in the understanding of collaborative strategy.

Harmony

This concept refers to the way actors work together. Using the term harmony may engender a connotation of idealism, akin to a Parsonian grand theory[9] - this is not the intended use of the term with respect to managing technology. The notion of harmony will refer in subsequent discussion to the combination of co-operative and competitive activities that enable work to be performed with a minimum of conflict. Harmony can be understood in terms of theatrical or operatic performances - the actors may not be predisposed to one another - yet they possess a capacity to perform and create an outcome that would be impossible without the co-ordination and sequencing specified by the rules of the script. Furthermore, the actors can express creativity even though the script influences the performance. Harmony therefore refers to the changing status of the collective outcome from working relationships operating among actors when managing technology.

Integrity

This final concept refers to the sense of unity that actors experience as a consequence of working together. Integrity is an elusive concept with moral overtones - actors sharing some distinctive notion of their identity which extends beyond themselves because the nature of their work requires performances to use shared rules. Actors know what defines their work, and can make normative judgements about how

[9] briefly, society is a system with needs, these needs foster co-operative work relationships.

adequately work is performed because of integrity. Integrity imparts an ability for actors to work together. The implications of integrity for managing technology is that a practice is performed with respect to both concrete and normative dimensions. Analyses of policies and interventions with respect to technology need to appreciate both these dimensions. The concept of integrity emerges in the final case study and is developed further in chapter seven.

Moving from the concept of technology through to integrity has seen a progression towards increasing complexity and corresponding obscurity. However, the difficulty of specifically defining these later concepts is not considered a shortcoming for improving the management of technology. To the contrary, these concepts foster hope. This hope is that new actions and understandings, spanning technology programmes and policies, will emerge from a continual appraisal of what constitutes appropriate technology that is developed from linkages fostered between the institutions of science and commerce.

Chapter Two

Perspectives for Managing Agricultural Technology

"What is truth?' John 18.38

1.0 Introduction

This chapter develops a theoretical frame to guide subsequent investigation of technology management in the NZ dairy sector. As an initial definition of technology, Farrington and Bebbington (1993) refer to a combination of hardware (seeds and machinery), methods (husbandries and marketing) and increments in knowledge (practical and scientific) used in agricultural systems. Technology also has a social dimension that involves the way actors align and interact to develop and use technology. Technology management is the development, distribution and use of technology by farmers, researchers and professionals to resolve problems or expand opportunities (Groenfeldt, 1989). Theoretical contributions to the investigation of technology management stem from technical and social science literature (see Figure 2.1). This chapter concentrates on the social science literature in the context of agricultural technologies. The discussion aims to integrate insights derived from several theoretical schools to improve the useful of knowledge systems and practice perspectives to the management of agricultural technology in a NZ dairy sector context. A knowledge systems perspective is developed before exploring how a practice perspective may enhance understanding of technology management issues. These issues are viewed as development challenges to organisations with some responsibility for the performance of agricultural sectors.

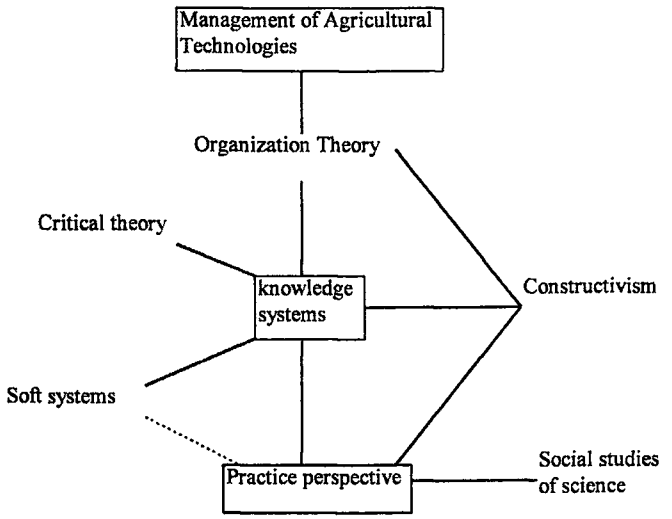

Figure 2.1: Chapter Outline

2.0 Managing Technology

General perspectives of technology have emerged from economic and social science literature. A general perspective of technology is developed in this section using these literatures before enlarging the discussion on the social dimension of technology management. This discussion will extend to encompass issues relating to agricultural technologies, being the social domain of primary interest in this thesis.

2.1 General perspectives on technology

Joan Woodward (in Pugh, 1985) claimed in 1958 to have conducted the first British investigation of the relationship between the principles of organisation prescribed in management theory, and business success in actuality. During her study Woodward discovered that organisational structure was related to the technical methods used by the firms.

> *'It appeared that different technologies imposed different kinds of demands on individuals and organisations, and that these demands had to be met through an appropriate form of organisation.'* (Woodward, p.60)

Woodward studied manufacturing firms and was writing for organisation theorists. Contributions from organisation theory to the management of technology are covered in section 3.0. Woodward's perspective is introduced here to demonstrate that an

appreciation of the need to link an understanding of technology with an understanding of human behaviour has existed for some time.

If humans organise their work in part according to the attributes of technologies in use, how do technologies emerge and change relative to human organisation? Clark (1987) rejects what he refers to as a traditional metaphor of science as *'a reservoir of knowledge from which technology draws the necessary quantum as and when needed.'* He argues instead that science and technology form part of a knowledge seeking continuum guided by 2 dominant forces: economic markets, and the goals of professional knowledge seekers. These forces are represented as poles in an interactive model that is communicatively bridged using the concept of paradigms (Kuhn, 1970). Paradigms provide a basis for heuristic development. Technological paradigms are more differentiated and systemic than scientific paradigms, and more vulnerable to competition and markets (Teece, 1988).

> *'Hence it should be clear that the notion of clear, unobstructed knowledge flows between differentiated S and T systems is a chimera. On the contrary the interrelations are so complex and the uncertainty so great that ways have to be found of ensuring an adequate rate of technological change, and the technological paradigm is precisely such a social device since its heuristic properties provide, as it were, a pathway of relative certainty in the midst of considerable ignorance.'* (Clark, 1987, p.39).

Clark's model depicts economic markets as an external force operating on a knowledge seeking process. It was the uncertainty of market forces on technology development that was of primary interest to Clark. The issue of uncertainty raises the question of decision-making with respect to technology. Schwarz (1993) posits an alternative perspective on technology to that of Clark, whereby technology and society are inseparable, technology is woven into everyday existence, contemporary society has a technological culture. Schwarz is particularly concerned with democratic choice in technology development decisions at a societal level. He argues for more appreciation of cultural agendas implied in technology debates. Furthermore, it is democratic discourse that underpins the social acceptance of major technological developments.

> *'For the functioning of democracies, technology assessment should be less of an ingenious tool for specialised decision-makers, and more of a social resource, a vehicle for public and political debate that informs social decision-making.'* (Schwarz, 1993, p.384).

Several dimensions to technology management have emerged from the forgoing discussion: a socio-technical dimension of action that requires some appreciation of organisations; a knowledge dimension, that requires some appreciation of epistemology; and a socio-economic dimension that requires some appreciation of decision making in relation to firms and society. This third dimension is explored further to provide a contextual setting to issues pertaining to the socio-technical and knowledge dimensions of technology management.

2.2 Managing technology for the firm and society

The problem of choice confronting investors and developers of new technology has often been managed through the use of selection criteria. Ramanathan (1994)

suggests three categories of criteria for screening technologies: techno-economic; organisational; and operating domain. However, screening criteria represent technology as a static entity. Furthermore the idea of technology selection implies a demarcation between the actors that provide technology and other actors who use technology. Kline and Rosenberg (1986), while accepting technologies have performance criteria, reject the notion of a linear transfer of technology from providers to users. Instead they developed a chain-linked model of innovation that depicts technology management as a highly dynamic and interactive process, involving the frequent use of feedback mechanisms to span various stages in the design, development and marketing of technology. Firms that play some role in the management of technology will access scientific knowledge as required at any point in the life of the technology. It is the uncertainty of development that motivates firms to access scientific knowledge, and market demand that inspires the development process. However the analysis of competitor actions is absent from their model.

Birnbaum *et. al.* (1994) undertook a content analysis study of 3 industrial sectors in the USA to determine the competitive actions of rivals under varying conditions of sales growth rates and sector maturity. Their study of manufacturers spanning 8 bit microprocessors, class 8 diesel truck engines and water treatment chemicals differed from many earlier studies of competition by concentrating on the actions of rival firms, rather than on a resource based perspective. Birnbaum *et. al.* analysed actions that created attributes of value to customers to realise competitive advantage. They found that even in technology intensive sectors like semiconductors, competitive advantages derived from either product or practice based technology were less than 20% of the total competitive actions used by firms. Technology actions[1] accounted for a higher proportion of total competitive actions as sector concentration[2] increased and sales growth rates declined. This increase in technology actions derived from service (not product) technology actions. They concluded that a critical determinant of success was focusing on a particular market segment and providing products or services that were non-reproducible by competitors. Yet this conclusion means a firm can only explain its successful technology strategies *a posteriori* as rival firms will continually strive to reproduce technologies that generate attractive economic profits.

An alternative analysis of competing technologies to that of Birnbaum *et. al.* was provided by Arthur (1989). The analysis by Arthur used a resource based view to argue that in some situations an increasing returns to scale effect is observed when technologies form the basis of competitive strategy. Arthur coined the term 'lock in' to describe how an economy can fail to select superior alternative technologies to the status quo. He cites the QWERTY typewriter keyboard, though other examples include the MacIntosh operating system and the βmax video system.

> *'Under increasing returns, competition between economic objects - in this case technologies - takes on an evolutionary character, with a 'founder effect' mechanism akin to that in genetics. History becomes important. To the degree that the technological development of the economy depends upon small events beneath the resolution of an observer's model, it may become impossible to predict market shares with any degree of certainty.'* (Arthur, 1989, p.128).

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[1] A category of actions in their classification of competitive actions was 'technology actions'.

[2] Where a small number of firms account for a large share of market transactions.

Arthur therefore argues that the fate of a technology can be explained in terms of a path dependent model of critical events in an historical structuring process that locks social developments into relatively stable 'pathways'. Hohn and Schneider (1991) applied the work of Arthur to investigate the development of a German research organisation (Fraunhofer Society) and German telecommunication services. Hohn and Schneider linked the notion of path dependence with a theory of critical mass, the latter claiming that explosive growth in the use of a technology occurs when a critical threshold is exceeded (Oliver *et. al.* 1985). Exploration of critical mass tries to find the trigger mechanisms that explain why growth accelerates, whereas path dependence looks for stabilisers. The development of a research organisation and a telecommunications service were considered comparable phenomena in a network context, whereby increasing numbers of actors were confronted with the choice to join or not join a network. They discovered that path dependency did indeed operate once a certain critical threshold in the size of a network was reached.

> *'In both cases [research organisation and telecom network] the process of network growth is characterised by increasing returns and growing benefit in being connected. As soon as the network exceeds a critical threshold the growth becomes self stimulating. The attractiveness of joining such a network increases with its size, and this self-reinforcing dynamic may lead o a monopoly for a research organisation, a telecom service or any other social network configuration.'* (Hohn and Schneider, 1991, p.120).

Hohn and Schneider observed that the fate of a technology or organisation can be precarious prior to the critical threshold event.

To recap the discussion so far, analysing technology management needs to appreciate the dynamic behaviour of organisations and technology, and competitive action, networks and collective action can influence the fate of a technology. Discussion will now turn to this issue of collective action in the context of organisations and technology. Dodgson (1989) reviewed a series of empirical studies on technology management to specify a research agenda for the investigation of technology strategy and firms. He was particularly concerned with the dearth of knowledge relating to technological collaboration.

> *'More needs to be known about the phenomenon of inter-firm technological collaboration. Is it likely to remain a permanent feature of corporate behaviour, or is it, as Sharp argues, a temporary response by companies to assist the process of industrial readjustment? Should governments, as some appear to be doing, uncritically accept the benefits of collaboration, without first understanding the effects they are likely to have on sectoral competitiveness and consumer choice? There are by now numerous examples describing the benefits of technological collaboration between large and small firms. Systematic study of the nature of these complementary links, the strategies that induce them, and sectoral and national differences which encourage them is, unfortunately, absent.'* (Dodgson, 1989, p.229).

Other authors share Dodgson's concern that inter-organisational technological collaboration is inadequately understood to assist with the strategic management of technology (Mytelka, 1990; O'Doherty,1990). Their concerns have identified a point of entry into literature from organisation theory that addresses technology management.

2.3 Inter-organisational collaboration and technology strategy

Alter and Hage (1993) developed a theory about co-operative behaviour between organisations to determine why firms or agencies co-operate. They observed the formation of collaborative relations among organisations that provided community-based care services following the deinstitutionalisation of medical and psychosocial care in two counties in the USA. Alter and Hage contended that the extent of collaboration observed among organisations depended on their willingness to collaborate and share risks, and on their need for expertise, financial resources and adaptive efficiency. In turn, the culture of trust, complexity of tasks and size of the collaborating organisations affected the above relations. Furthermore, specialised niche market opportunities must be available to organisations. The authors were primarily concerned with the emergence of collaborative relations, not the outcomes achieved through these relationships.

Another USA based study sought to identify the outcomes of collaborative relationships in the pharmaceutical industry (Gordon, 1995). Gordon was particular interested in how strategic alliances, being long term relationships of strategic intent for mutual benefit, were used to achieve strategic outcomes. She established that her subjects pursued alliances to leverage core competencies, and that the management of relationships was significant to alliance outcomes.

> *'If one accepts the managers' view that alliance outcomes are a function of relationship quality, alliance structure, strategic logic and expectations, and wishes to understand the nature of these influences, several steps must be taken.'* (Gordon, 1995, p.556).

The steps referred to above included a need to improve the definition and measurement of concepts like strategic logic and alliance outcomes such that comparison is possible across alliances while not restricting the customization necessary for each unique alliance circumstance.

The subjects in the Gordon study were large corporations, similar to those studied by Gibson and Rogers (1994). In the Gibson and Rogers' study a microelectronics and computer technology R&D consortium was investigated. The consortium was an experiment in R&D collaboration focusing on precompetitive (production) research judged by the shareholder companies to be strategically important to their independent futures. The consortium was considered a disappointment in terms of its contributions to computer architecture and design tools, and software development. However, the authors contended the consortium had most impact on USA industry as a laboratory for analysing technology collaboration.

> *'It is in learning about the process of technology collaboration where MCC [the consortium] may have its greatest impact on the member companies in particular and enhance U.S. industrial competitiveness in general. MCC has served as an important real-life laboratory to study the barriers and facilitators of collaborative R&D leading to technology application and commercialization. MCC has been an important stimulus and model to R&D consortia and alliances that have followed.'* (Gibson and Rogers, 1994, p.542).

The notion of a *technology of consorting* was put forward as a primary success technology emerging from the MCC experience. This *technology* comprises the heuristics learned by MCC actors and formalised by the authors. An example of an

heuristic lesson was that senior managers' visions for inter-organisational structures must be enacted by operational management. Operationalisation required that the actors were motivated and shared goals; that they were located within a proximity sufficient for physical and cultural interaction; and that they communicated interactively. A fear of survival was not a sufficient motivator to sustain co-operative action. At the level of individual action the authors observed that some actors were particularly adept at facilitating inter-organisational collaboration. These *mediating actors* were typically not rewarded for their contributions because memory of their efforts was short term and outcomes from their work were often subtle but of a high impact in the long term. Actors mediated by performing as product champions, spanning organisational boundaries while performing essential activities for managing technologies.

> *'The entrepreneurs that successfully spun technologies out of MCC were product champions who had a clear vision of a problem that they were trying to solve and its market potential as well as an intimate knowledge of the technology they were developing. Still, they had to be adaptable and listen to business, financial and legal advisors as they took their technologies to market strength.'* (Gibson and Rogers, 1994, p.548).

Heterogeneity of consortium membership acted as a barrier to collaboration, yet contributed a high competitive advantage if resource leveraging was achieved. Finally, the consortium venture experienced a high degree of unpredictability from collective actions, with some initial successes spawning inter-organisational conflicts, and other collaborative actions yielding windfall gains like new ventures emerging within each firm. Gibson and Rogers concluded from their study of MCC that advanced technology was not the cause, or even a major catalyst to the emergence of virtual companies and seamless organisations - rather technology was an additional tool for collaborating and that the real challenges for collaborating organisations were behavioural and managerial. Interestingly, in their study the need for a culture of trust did not emerge as a significant factor in the evolution of collaborative actions.

In contrast to the MCC experience, a European study determined trust to be a significant influence on inter-organisational collaboration (Hausler, *et.al.* 1994). In a case study of collaboration among German firms to produce an adhesion technology, trust emerged as a modular, cascade like process whereby a wide scientific-technical network of actors initially explored technical problems. The process ending with a small group of actors from a few companies and research institutes collaborating in an R&D project. The project was government-sponsored, with public officials judged by the authors as catalysts to building co-operation among the actors. Under these conditions the actors did not deem contracts an adequate or important governance mechanism. Contracts were likened to *marriage contracts* that referred more to workable exit conditions, than operating conditions. A similar conclusion emerged from the findings of a Dutch investigation into a government subsidy scheme for shipping industry technology (Noorderhaven, 1990). The suggestion of exit conditions implies that relationships can and sometimes do breakdown. This raises the issue of conflict and the need for negotiation processes to manage conflict. Pruitt and Carnevale (1993) propose that negotiation can be understood as a sequence of tactics that actors use to derive an agreed course of action. Critics of this view by Pruitt and Carnevale argue instead that negotiation is an aspect of actors' relationships whereby

new directions for the relationship are worked out. Sense making is the critical dynamic in the process, '*A collective rationale, linking what is happening now to what has happened in the past and what needs to happen in the future.*' (Morley, 1992, p206.).

This investigation of literature addressing inter-organisational collaboration has relied on studies of corporations that manufacture advanced technology. In summary, the task of managing collaboration divides between two domains. In one domain the management of organisational needs tends to issues like dependencies for leveraging core competencies. In the second domain the primary concern is managing relationships, like goals and communicative competencies. Contracts and negotiation processes are used as tools to manage the evolutionary and often unpredictable nature of relationships. The role and limits of using formal contracts in technology based relationships, and the use of imagery like the marriage metaphor raises the question, how do actors construe their work relationships? How do these actors make sense of their world and work out their *differences of opinion* to act in harmony? These questions shift analyses from that of resource bases to the *construction of perspectives* on technology management. This shift does not reject the crucial role of resources in collaborative work, rather it views resource issues *through the eyes* of the actors working in collaborative programmes. To approach these issues the next section introduces a constructivist perspective and develops a metaphor of theatre to inform technology management.

2.4 Constructivism and the metaphor of theatre to inform technology management

A discussion of constructivism requires some clarification of the relationship between knowledge and the theoretical notions discussed in this chapter. Knowledge is justified true belief, *'we conclude that a man knows something only when his belief is true, completely justified, and the justification is undefeated.'* (Cornman and Lehrer, 1974, p.64). This definition identifies knowledge dimensions of belief, truth and justification that have been a primary concern in epistemological investigations over many years. Griffin (1991) classified communication theories according to two epistemological 'world views', viz.:
World View I: reality is something 'out there' to be discovered by adopting a detached scientific stance as observer for establishing cause and effect relationships among variables, and thereby generalising and predicting behaviour of observed phenomena.
World View II: reality is something requiring interpretation, being in a constant flux and can only be experienced in the lives of individuals. Truth emerges more from observing patterns of human relationships in natural settings, than from controlled laboratory experiments. *'World View II theorists feel successful when they've made a perceptive interpretation of a communication event.'* (Griffin,1991, p370).

Constructivism is a general term that refers to the way humans as social actors construct their view of reality (Berger and Luckmann, 1966; Berger, 1969). The constructivist position is therefore aligned with those theories classified as *World View II.* A protagonist for using constructivist perspectives towards advancing organisation theory is Karl Weick. The work of Weick has contributed understanding

with respect to strategic aspects of collaboration. He argues that human nature seeks to eliminate ambiguity inherent in information, yet organisations are typically complex and diverse social settings (Weick, 1995). Organisations require complex interpersonal networks to make sense of the ambiguity in information. Weick developed the notion of *coupled systems* to denote the strength of bonds operating among networks of actors. A loose coupling refers to indirect but related events in actors lives. A worker may experience a domestic dispute that carries over into his work environment and impair the work of colleagues at a critical period in a performance review. An assessment of workers' collective action is therefore loosely coupled to the domestic experiences of one team member. A tightly coupled system has strong bonds in the network, like food quality control protocols that ensure all workers maintain standards regardless of seasonal variations in product supply.

> *Because such systems [nuclear power plants] are tightly coupled and involve complex transformation processes, unexpected sequences of events are commonplace. These accidents, which are "normal", considering the obscurity of the technology, are neither familiar or easily solved. The combination of complex technology and limited expertise makes for incomprehensible events. The sense making dilemma inherent in these technologies is capture by Perrow's observation that "warning of an incomprehensible and unimaginable event cannot be seen, because it cannot be believed."'.* (Weick, 1995, p.87).

Weick claims social systems like organisations evolve through a three stage process of enactment, selection and retention. Actors can only interpret actions they have already taken. Under enactment actors organise their environment rather than discover some rigid set of organisational boundaries. Selection is retrospective sense making. Two organisational tools help this sense making: rules, or stock responses that have served well in the past, and the *double interact cycle*. This cycle is the basic unit of interconnectedness in coupled systems. A cycle consists of an action, a response and an adjustment. Retention is the way coupled systems remember. Retention creates a network of rules that act as a collective memory in the system. This collective memory provides stability to the system. Excessive retention reduces an actor's flexibility to respond to information. Organisations fail when they fail to act, or when they lose flexibility by relying too much on rules that apply to past events.

The strategic import of Weick's work relates to the notion of organisations as seamless (diffuse boundaries) social domains that possess some mix of rules for inherent stability, and cycles for negotiated understanding. Cycles reduce ambiguity in complex situations but they are a relatively expensive tool to operate. As complexity increases the ratio of cycles to rules increases to make sense of the situation. Weick suggests that in complex situations organisational leaders ought to continually discredit much of what they already know and argue, contradict and doubt conventional wisdom. Managers cannot hope to grasp the intricate details of the many disciplines under their control, but they can provide effective leadership '*by treating memory as a pest*', and by using the art of paradox to provoke inquiry among actors in the coupled system. Paradox refers to the way managers question the work of actors to create doubt and provoke inquiry and thereby redress the mix of rules and cycles used to make sense of complex situations.

> *'The overall point is that information technologies are driven by decision rationality, not action rationality or narrative rationality. Furthermore, it is difficult to override*

> *decision rationality when that rationality is built into the technology by engineers who are true believers and when that technology is run by people at the top who are far removed from the action that is unfolding.'* (Weick, 1995, p.178).

How has Weick's theory of sense making been applied to the analysis of technology management? Kreiner and Schultz (1993) studied informal university-industry research collaborations to determine how successful relations emerge. They identified three stages in the formation of a network to barter services between actors. First, actors serendipitously discover opportunity to work together through personal encounters. Second, as opportunities are explored collaboratively the actors come to realise that something more than incidental communications are being shared, tasks are being shared in a mutual development of concepts and workplans. Third, collaborative relations become an entity that is recognisable to colleagues in the extended working community. Kreiner and Schultz interviewed actors involved in competitive technology development arenas. They found shared projects emerged not so much because knowledge and experience were blended, but because an unplanned blending of actions was conducive to innovation. Consistent with Weick's theory, a rationality of action preceded a rationality of decision making. Trust was a necessary condition for collaborative work to emerge, consistent with studies discussed previously.

> *'Indeed, trust was a recurrent theme in the researchers' own description of networking. If asked, they would operationalize trust to mean that entrusted knowledge would not be misused, stolen or leaked to third parties. Anyone being accused of such an act would rapidly become a leper in the field. Illegitimate use of shared information was considered* **the** *deadly sin of networking, and the sanction against such a sinner would be to close his window on the 'frontier' in the future.'* (Kreiner and Schultz, 1993, p.203).

The Kreiner and Schultz study concurs with Weick, in that patterns of interaction for developing new technology are characterised by anarchy and licence, not planning and control. Actors informally appropriate organisational resources and divert these into unauthorised projects and relationships. Organisations faced a dilemma of soliciting external knowledge while protecting their own resources, with a network norm of mutual trust operating among actors.

> *'The question remains, however, of how to use paradoxes constructively in the exercise of premise control*[3]*. It is our interpretation of the managerial strategy in our cases that its aim is to ensure the exercise of 'sound' judgement by the researchers engaging in networking. Since 'soundness' is an 'ex post facto' assessment, what R&D managers really can aspire to is to ensure that judgement is exercised at all. They do this by constantly reminding the researchers of both sides of the dilemma. By constantly keeping the dilemma alive and present, any routinization of networking behaviour is prevented. Even if networking is ordinarily conducted, it is meant to be treated, every time, as an exceptional event. For example, nobody should be encouraged to reveal confidential plans and ideas* as a matter of routine*; and at the same time, nobody should be encouraged to keep such plans and ideas secret* as a matter of routine.*'* (Kreiner and Schultz, 1993, p. 206).

To conclude this section on constructivism, knowledge in organisational contexts is socially constructed. When organisations are viewed through the lens of constructivism they appear not as static legal entities, but dynamic coupled systems of

[3] control of the preconceptions which guide the process of enactment (Weick, 1988).

actors that may span several *legal entities*. The task of managing technologies therefore needs to appreciate the social dynamics of the situation, with its associated uncertainties and ambiguities. Managers may perform more effectively by using paradoxical messages with the actors involved in inter-organisational collaborations, rather than exerting control over these actors by using formal planning routines.

There remains a need to search for a means to represent these fragmented insights to collaborative technology management. Constructivist literature frequently resorts to metaphor and allegory to frame theoretical messages. Weick's concept of coupled systems uses a biological metaphor to represent an understanding of sense making processes in organisations. A *theatre* metaphor has recently emerged in the context of technology management. Recent advocates of the theatre metaphor have sought for a convergence of resource and social concerns in a constructivist framework (Khatoonabadi and Bawden, 1993; van Lente, 1993). Theatre implies a dynamic unfolding of possibilities through social interaction. An unfolding that has technology becoming a very human faculty, an acting out to grasp the future. Theatre enables actors to experiment with ideas while they simultaneously grasp for a new future through technology.

> *'This self-organising character, this movement of an unreal projection converted into reality, is particularly striking in the case of technology. But technology only expresses something that is deeply human. ... The roots of all action is in the future, in the projections we design and consequentially try to convert into reality. "Body and soul are things, but I am a drama, if anything an unending struggle to be what I have to be ... to find means and ways for realising the program that we are." So as a consequence "man has to be an engineer no matter whether he is gifted for it or not." The reverse is true as well: engineers have to be like novelists. They have to write forceful fiction and make it come true as well. Actors developing technology, to paraphrase Ortega, conceive for themselves the fanciful figure of a future technology, and for the sake of converting into a reality, they, as well as others draw into the fancy, do all the things they do. Whatever technology may be in the present, it is rooted in the future.'* (Van Lente, 1993, p239.)

Khatoonabadi and Bawden (1993) have worked with Iranian nomads and Australian Aborigines using *Forum Theatre* as an extension method. Forum theatre requires actors and audience to both be active in the construction of the drama. Here theatre is no longer a metaphor but a method, *'In this case drama is not a medium for communication, it is the systemic communication, the message.'* Though forum theatre can include image making, creative movement, exploratory games and creation of scenarios etc., the authors found story-telling to be the most compatible and adaptable technique in both cultures. This finding is consistent with developments in an emerging methodology termed *Narrative Analysis* (Abell, 1987; Curtis, 1994; Mishler, 1991; Pacanowsky, 1989; Traweek, S. 1992; Waldenstrom, 1994). Forum theatre seeks to explore previously inaccessible cognitive realms of actors.

> *'Improvisations involve spontaneity, creativity and the participants' Clown. Spontaneity is an essential ingredient in finding one's Clown that is tacit knowledge, the language of the Clown, is a means through which we develop spontaneity in life ... shared fun and enjoyment. Buried within us, each of us has our own Clown, an irreducible playful essence that we rarely reveal in ordinary life.'* (Khatoonabadi and Bawden, 1993, p. 528)

Theatre can act as an inspiring metaphor for technology management situations, and it has inspired innovative action research among groups. The risk with any metaphor is that it becomes an ideology to the actors using it. Technology management **as** theatre can become technology management **is** theatre, where theatre comes to specify what ought to be. This risk can increase when methodology inspired by a theatre metaphor is seen to be an end in itself.

This discussion of theatre concludes the analysis of technology management. It is now necessary to develop the agricultural context for technology before exploring theoretical developments in knowledge systems and practice.

3.0 The special case of agriculture with respect to technology management

This section continues with the theme of collaboration developed above and applied to the management of agricultural technologies. Several perspectives on the role of social science in agriculture are discussed. Issues arising from these perspectives are explored before identifying the need for further research and development in knowledge systems and the analysis of practice.

Farming System Research (FSR) has been defined as any research that views the farm in a holistic manner and considers interaction in the system (Byerlee, *et.al.* 1982). This general description has caused confusion among workers in the field as there is little agricultural or rural development work that cannot claim some relationship with the FSR. Byerlee, *et.al.* (1982) were concerned with issues of technology design from FSR and were therefore more specific in their definition. Characteristics of FSR of importance to technology design include that it:

a) generates technology to increase resource productivity for identified farmers in the short term;
b) is based on a farming system perspective;
c) uses on farm research methods.

The authors specify a sequential data collection strategy to obtain agrobiological and socio-economic data on key variables of the farm system at least cost. They claim methodology was least developed in the area of farmer circumstances, *'Technology design consists of identifying important opportunities and then prescreening technological alternatives for each research opportunity in light of farmer circumstances.'* They called for a need to explore bottom-up-farmer-first means of achieving change. In his critique of Byerlee, *et.al.*, Hildebrand (1982) agreed with the need for multi-disciplined teams and social research, but was concerned the authors failed to recognise the role of extensionists in FSR, nor did they appreciate the difficulties in managing multi-disciplined research. These agricultural economists were specifying a social science role for managing technology, but how did the social scientists view their role?

Groenfelt (1989) gave a synopsis of the role of social science in agriculture technology management. He identified 4 themes: setting research agendas; helping agricultural technologists target users; adapting technology to help adoption; and improving institutional arrangements for benefiting from technology. Of these

themes, Groenfelt considered the analysis of institutional arrangements the most neglected in the field of social science. He argued for the inclusion of user perspectives in all stages of technology design, development and use. Farmer perspectives can be difficult to access and interpret, as farmers initial responses to questioning cannot always be taken at face value. A developing country example was given whereby farmers planted after a religious festival, but the logic for this action involved a complex web of pest, climatic and market cycles that were not provided as initial justifications for farmer actions. Groenfeldt coined the term *mediating* to refer to the role of social scientists to act as boundary spanners (Gibson and Rogers, 1994).

> *'In addition to gathering information from farmers, Rubin interacted closely with research station agronomists and breeders, conveying the response of farmers, and learning new questions to ask. This type of mediator role for the social scientist has become a classic one in development work. In Rubin's work, a mediator role was played at two levels: first the agricultural experiment station where her study focused on a specific, field-oriented problem, and second, the two centers she was affiliated to where feedback from her work contributed to an enhanced farmer perspective in the research agenda.'* (Groenfeldt, 1989, p.5.)

Groenfeldt was also critical of the Farming System Research (FSR) work performed at the time of writing, claiming the social science perspective required more appreciation of the community dimension in farm decision-making. He suggested devolving authority from government agencies to local farmer associations would improve FSR. By devolving authority he expected a shift in emphasis from technology development to systems research and adaptation by intermediate users. Similar concerns about developing country FSR programmes were raised by Chambers and Jiggins (1987). They argued that resource-poor farmers were largely neglected in the research decision-making process, and some redress was required to balance the relative influence on research priority setting by scientists, resource-rich farmers, and resource-poor farmers. A call was made to acknowledge the value of local knowledge in technology management programmes.

> *'Yet informal R&D is not only widespread but necessary for farmers to survive, adapting to new and variable conditions. Many observers have remarked on its prevalence and effectiveness. In one sense, farmers are continuously experimenting and learning, in that they rarely repeat exactly what they have done before, and conditions continuously vary. More directly, it is common for farmers to be interested in new crops and new varieties and to be enthusiastic about trying them out systematically. Home gardens are often sites for such trials, undertaken with low risk because they are on a small scale. Farmers are also reported to experiment with controls. Not only may they have little difficulty in understanding the concept of a control; they may already be familiar with it.'* (Chambers and Jiggins, 1987, p.113).

Most development of the social perspectives in FSR has emerged from experiences in developing countries. Reid (1996) reviewed contemporary FSR literature to determine its potential role for the agriculture of developed countries. She distinguished between FSR-X (extractive) and FSR-P (participative) to characterise the role of researchers in the research process. Her classification of a programme is therefore based on the relative participation of farmers in the programme, and their relative ownership of the research process. A continuum of programmes extended between two poles, at one extreme researchers were represented as 'outside' the farm situation extracting information, through to researchers operating within programmes that enabled farmers to control their own research programmes. Reid contended there

was also a conceptual continuum of changing paradigms extending from a linear transfer of technology model through FSR-X to FSR-P and beyond to an emerging paradigm that incorporates soft systems methodology[4] with an emphasis on action research (Argyris *et.al.* 1985; Foote-Whyte, 1991). It is not clear what Reid considers this emerging paradigm will be, though some would argue soft systems methodology and action research have been commonplace in some types of FSR for some time (see for example Bawden, 1989; Bawden and Macadam, 1991).

The issue of farmer (or other end-user) participation in technology development has emerged as a critical aspect of programmes. Okali *et.al.* (1994) considered farmer participation in technology development had been of two types. One type of review defines the steps in the process of technology development. Participatory technology development (PTD) has been represented as a 5 step process (see Box 2.1).

Box 2.1 Participatory Technology Devlopment

1. How to start	2. Find things to try out	3. Try out new activities	4. Share results	5. Sustain the process
engage in a relationship with the farmers	take decisions on what to do	execute	disseminate results	when external support withdraws something concrete must remain
know them better	decision on priorities	improve	ensure wide diffusion	
make them know you	start up a schedule	get interesting results		

(source: Okali *et.al.*, 1994)

The second type of review focuses on the nature of the participation in a programme. Pretty (1995) offered a typology of participation spanning from passive participation, whereby participation merely involved telling participants what is happening, through to self-mobilization, where participants were self-directed actors. Pretty considers programmes located in his first 4 categories will not achieve a change in participants actions.

> *'Great care must, therefore, be taken over both using and interpreting the term participation. It should always be qualified by reference to the type of participation, as most types will threaten rather than support the goals of sustainable agriculture. What is important is to ensure that those using the term participation both clarify their specific application and define better ways of shifting from the more common passive, consultative and incentive-driven participation towards the interactive end of the spectrum.'* (Pretty, 1995, p.174).

Farrington and Bebbington (1993) proposed classifying participatory approaches using the dimensions of depth (as elaborated by Pretty) **and** scope of subject matter.

[4] SSM is discussed in section 4.0 in the context of agricultural knowledge systems

Using a simple quadrant diagram based on case study evidence they characterised participatory approaches along a vertical axis from narrow to wide subject scope, and along an horizontal axis from shallow to profound depth of participation. This classification identified deeper levels of participation tended to rely more on group than on individual approaches. Furthermore, empowerment of participants depended in part on the willingness of professionals to disburse their functions among the participants.

A plethora of participatory approaches have been used in recent years. Pretty considers several defining principles are common among participatory approaches, viz.:

1. they possess a defining methodology and systemic learning process for cumulative learning by all participants;
2. multiple perspectives seek diversity rather than use average values to instruct action in complex situations - participants appreciate that all views of activity possess the participant's interpretative bias;
3. group learning processes dominate, complexity of the world is revealed through group inquiry
4. the approaches are context specific;
5. experts facilitate to transform existing activities to bring about change;
6. learning processes lead to sustained changes in actions of participants;
7. an assemblage of participatory methods [ie. team, sampling, dialogue and diagramming methods] constitute unique systems of inquiry.

Participatory technology development has come under review in terms of its contribution to the understanding of farmer decision-making (Jiggins and De Zeeuw, 1992; Okali *et.al.*, 1994). In an attempt to improve the conceptual and methodological clarity of PTD in relation to farmer decision-making, Okali *et.al.* proposed focusing on the contrast between norms and behaviour of farmers, *'Thus we envisage a situational analysis which allows one to distinguish between what is normal practice (i.e., within the bounds of normal variation for a given farm system) and what is actually being done at a given time and place.'* Their suggestion is operationalised as a set of three questions to the farmer:

1. archetype, or system norm
2. normal work by farmer
3. actual work by farmer

Comparative analysis of questions distinguishes between disagreement over meanings (compare 1 and 2) or experimentation (compare 2 and 3). The questions are directed at the farmer but are used to guide dialogue and reflection between farmer and researcher.

In constructing an agricultural context for understanding technology management and the role of collaboration, this section traced FSR developments in general, and the emergence of participatory approaches in particular. Conceptual advances in PTD have addressed issues at the level of organisational alignment and the associated function of mediators. At another level PTD focuses on the farm system, and the behaviour of farmers as decision-makers. It remains to align the insights on technology management that have been derived from organisational theory and from FSR. Subsequent sections seek this alignment by attending to the dimensions of knowledge and practice.

4.0 Agricultural Knowledge Systems[5]

An Agricultural Knowledge Systems (AKS) perspective arose from the convergence of technical and social scientist views on the need to improve the representation of knowledge development and use towards agricultural innovation (Engel, 1995, p.2). An AKS is a conceptualisation, it does not exist as a tangible entity, though the components of AKS are often visible in terms of computer hardware and software, discussion groups and organisations. The conceptual nature of AKS has provoked a continuous refinement of its definition over the past decade. An AKS is used here to refer to **the concept that specifies a social domain of knowledge construction and use for the benefit of those actors that interact in that domain.** The systemic behaviour of an AKS can be represented as a dynamic system of actors that interact to construct knowledge. In addition to the definition above, there must be added an appreciation of the continuously changing status of knowledge systems, both in relation to the construction of knowledge, and in relation to extent of actor interaction. A dairy sector can be viewed as an AKS with a mix of actors interacting to fulfil their individual goals and at times deciding to work together to solve common problems (Van Beek, 1991). The AKS perspective therefore assists with the analysis of institutional arrangements for the design of interventions that seek to improve the harmony among the performances of the various actors. There are many similarities between the AKS perspective and the concept of marketing channels (and channel alignment), though the former is primarily concerned with the social construction of knowledge, whereas the latter is primarily concerned with the accumulation and distribution of instrumental rewards. In particular, the AKS perspective represents the nature of actor relationships as a system, whereby innovation is an emergent property of that system.

This section first traces the theoretical origins of AKS before discussing its role in the analysis and management of issues relating to agricultural technology. The AKS perspective to managing national research and extension resources developed in response to the perceived inadequacies of the traditional adoption diffusion model elaborated by Rogers and Shoemaker (1971). The adoption diffusion model became the pre-eminent theoretical framework for extensionists in the early 1970's, providing a rational explanation of human behaviour towards the use of new technology. As extensionists confronted more complex problems such as sustainable resource management, they found the adoption model less useful. Extension researchers began seeking theories that explained why groups emerged and chose to work together, or why competition and conflicts arose when developing and using technology in an ecologically sensitive era like agriculture. Similarly, the adoption model was found wanting when confronted with the management of extension services in privatised economies.

> *'...One problem is that the recent Privatisation of the extension service forces staff to search for "knowledge products" which can be sold to farmers. This pressure has emphasised the expert role of extension workers and the role of knowledge as a commodity. It is too early for solutions to have crystallised. In all, the experience*

[5] Also referred to as Agricultural Knowledge and Information System (AKIS) and Knowledge and Information System (KIS) approach.

> *to date seems to show that the linear model*[6] *(Kline and Rosenberg. 1986), according to which scientific research is the source of innovations, extension the instrument for their transfer and farmers the receivers and utilisers, is inappropriate.'* (Röling, 1994, p283.)

The AKS perspective is described as a diagnostic frame to explore the way organisations interact to generate and use knowledge (Engel, 1995). Engel traced the emergence of the AKS approach to a convergence of intellectual traditions spanning a wide variety of professions. While not denying the eclectic convention in the AKS fraternity, I consider the intellectual pedigree of the AKS approach derives in the main from Habermas (1972), and Checkland (1989) whose works are combined to form an abstraction of the social domain in agriculture[7]. Constructivism represents a third intellectual pillar to the AKS intellectual edifice (see Figure 2.1). Each of these theoretical schools are now investigated for their contributions to the AKS perspective with respect to technology management.

4.1 Constructivism and AKS

Constructivism is referred to briefly here, following the more extensive discussion in section 2.4. The knowledge dimension is constructed by the actors in the AKS. Analyses of the construction of scientific knowledge in the laboratory have been particularly informative to the development of the AKS perspective. Knorr Certina (1981) argued scientific inquiry involving laboratory work is constructive rather than descriptive, the laboratory being the venue to create artificial worlds. Scientific knowledge therefore exists in the making, not as a 'ready made' finished article (Latour, 1987). Furthermore, Latour (1991) observed a combination of knowledge, actions and objects that together create agency[8], which social scientists artificially and unproductively dissect using hermeneutics[9].

> *'You will see a collective of practicing scientists turning with skill around instruments, trying to interest and to convince each other, and in order to do so, introducing into their exchanges slides, tables, documents, photographs and reports ...'* (Latour, 1991, p8)

Latour therefore contends that social scientists use hermeneutics to lend credence to their use of research methodologies when debating with biophysical scientists. The move to hermeneutics widened the gap between physical and social science, forming a counterproductive wedge between the two science schools. Consequently, the important problems for science, such as studies of sustainable agricultural systems, are falling in the gap created between the schools. Functowicz and Ravetz (1994;

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[6] Röling's use of the phrase '*the linear model*' here draws on design literature. There is a continuity in thinking between the adoption diffusion model used in extension, the linear model in design and engineering, the product life cycle in marketing and the subsumption model in philosophy of science (see Gremmen, 1993 below).

[7] Habermas provides the epistemological, and Checkland the ontological foundations of the AKS approach.

[8] the capacity for voluntary action

[9] The science of interpretation, with an interest in both the content and form of what is being interpreted. Hermeneutics stresses the need to understand the context, or the whole discourse, to interpret a part of what an author is saying, and vice versa (the hermeneutic circle).

1993; 1990) have repeatedly argued that the challenge for science is to overcome problems of systems uncertainty which requires a new order of science, referred to as a second order or a post-normal science. As the decision stakes for society increase there is a corresponding increase in the demand for science to provide a scientific management of uncertainty that accommodates a plurality of perspectives and problem contexts. From an AKS perspective this physical-social gap can represent a lack of harmony between the sciences involved in agriculture (Röling, 1995).

> *'From a constructivist perspective, the social sciences can play an important role in agricultural science, not only by understanding and stimulating the collective learning process but also because they themselves help shape human sense making. Social science cannot send a man to the moon (ie., excel in instrumental action), but it can greatly influence the way people think about themselves. That belongs to the mandate of agricultural science.'* (1995, p.11)

4.2 Soft Systems and AKS

To improve the specification of knowledge domains required the AKS developers to investigate the **soft systems** literature. In particular, the AKS school approached Checkland (in 1990) and his soft systems methodology (SSM) to assist with the analysis and design of interventions that promote innovation in agriculture. Checkland (1989) uses analogies with organisms to define systems. His work produced an abstraction (the soft systems concept) of an abstraction (conceptual systems - like an AKS), which has underpinned the formulation of definitions and relational explanations in AKS theory.

General Systems (von Bertalanffy, 1970) are defined by their purpose (problem domain), boundary conditions (the criteria that includes some items and excludes others) and their relationship to other systems (the mechanisms of interaction between systems). The autonomy of a system is dependent on interaction with other systems. Systems are organised and arranged in an hierarchy - a system is comprised of components or subsystems, and is itself a subsystem of some larger system. Systems are purposive, operating on inputs (from outside the system) to generate outputs that are consistent with the objectives of the system. The way systems interact to perform their purpose generates emergent properties. These properties are synergistic outcomes of system interactions - they possess capabilities greater than the sum of the component system capabilities. Systems research typically handles complex dynamic problems like sustainability and quality management tasks. When systems are developed for dynamic problems they are characterised by feedback mechanisms that enable adaptation.

Soft systems refer to the constructs that actors share in a common domain of action. Soft systems do not claim the world comprises complex systems, but that actors can organise their inquiry of complexity as a systemic learning process (Checkland, 1995). Soft systems inquiry emerges as actors share learning experiences associated with a common problem, and often evolve the building of rich pictures to accommodate conflicting objectives. Soft systems are participatory by nature. Bawden (1995) identified several contributions that the soft systems perspective offers to FSR by:

- providing a systemic framework for including farmers in decisions determining what constitutes improvement
- enabling differences in opinion between farmer and researcher to be made explicit
- provides a vehicle for other stakeholders to be included in the development process.

It is the reflexive nature of soft systems as shared constructs for learning that is of importance to the AKS perspective. Some systems of inquiry involve actors competing and even conflicting with each other to achieve their separate goals. Conversely, in some circumstances actors will harmonise their actions to manage complex situations, with a possible corollary that innovation emerges as a property of the soft system (Engel, 1995).

4.3 Critical Theory and AKS

Röling (1995) seeks to improve the harmony among actors operating in knowledge systems. He makes use of **critical theory**, and in particular the work of Habermas to build harmony in AKS. Habermas (1972; 1984) aimed to create a body of knowledge that enabled values to be discussed and selected on a more rational and consensual basis than is currently the case (particularly in social science investigations). Habermas[10] argued **that communicative forms are primary, reasoning is by nature regenerative and is embedded in language.** In later work Habermas (1984) distinguished 3 rationalities: instrumental rationality whereby actors seek to control systems for instrumental gains; strategic rationality whereby actors seek success in terms of control over other actors; and communicative rationality whereby actors seek solutions, meaning, purpose and fulfillment through improved social interaction. The AKS perspective is particularly concerned with communicative rationality (Röling, 1995).

> *'The essential contribution of critical theory to AKIS, as far as I am concerned, is that it has moved earlier AKIS thinking from* ***instrumental*** *rationality (AKIS has a given purpose), through* ***strategic*** *rationality (actors in the Long[11] sense struggle in the arena*

[10] Habermas submitted 5 theses (see below) to construct a theory of communicative action, arguing the implications of these theses for science are as follows:

- the culture of science is not derived from the information content of theories, culture derives from emerging enlightenment among scientists.
- Ideology is a distorted form of communication that affects the capacity of groups to arrive at satisfactory agreements.
- Science is a type of ideology - a systematic distortion which misuses the rules of language - a common cause of failure to achieve consensus.
- The concept of a pure theory is ideological - its adoption by science does not affect practice, it affects the self identity of science.
- Science fails to reflect on values yet it manipulates nature

Thesis 1. The achievements of the transcendental subject have their basis in the natural history of the human species.

Thesis 2. Knowledge equally serves as an instrument and transcends mere preservation.

Thesis 3. Knowledge-constitutive interests take form in the medium of work, language, and power.

Thesis 4. In the power of self reflection, knowledge and interest are one.

Thesis 5. The unity of knowledge and interest proves itself in a dialectic that takes the historical traces of suppressed dialogue and reconstructs what has been suppressed.

[11] See for example Leeuwis, C., N. Long, et al. (1991). Equivocations on Knowledge Systems Theory: An actor-oriented critique. European Seminar on Knowledge Management and Information

> *to realise their objectives) to* ***communicative*** *rationality focusing on synergy which arises out of* ***interaction****. Facilitating innovation is facilitating their synergistic interaction. Habermas sees communicative action as the one course to innovation and learning our way to a sustainable future, hence the interest in interaction, collective action and social learning.'* (Röling, 1997, per. comm.)

Habermas was particularly concerned with the link between science and technology and the state, whereby rational purposive action spreads from economic concerns to include political consensus and value construction. He calls for collective decisions regarding science and technology, and rejects the view that technology is an aspect of the external world over which individuals have no control. Technology is a product of society's communicative and decision-making practices.

If Habermas has influenced the theoretical basis of AKS, he has also affected the direction of methodological development. Habermas claims communicative competence is required for humans to take charge of their values - an ideal speech that enables critical conscious reflection and deliberation to apply common values to concrete problems. Communication overcomes the barriers to interaction and advances humanity. Speech acts provide the units of analysis to study communication and culture. Habermas is therefore rooted in the science tradition, and is sceptical of theories that have no obvious reference to observable events. He is concerned to raise phenomena to an observable level. Cultural theories are to be tested by scrutinising language with reference to social interactions.

Further understanding of the AKS perspective is attained by reviewing substantive analyses of technology management in recent years. Van de Fliert (1993) compared farmers using sustainable rice cultivation practices in Java with those farmers using the prevailing high-external-input technologies in the context of Integrated Pest Management (IPM). The AKS perspective informed an evaluation study spanning 5 growing seasons that observed the actions and perceptions of farmers in 4 villages. All farmers were exposed to an intervention programme promoting high-external-input technologies over a 20 year period. The study determined farmers were by-and-large using high-external-input technologies, but their methods differed substantially from those recommended by the government advisers. Furthermore, the training experiences of farmers influenced the way high-external-input technologies were used. Farmers trained under a field school system that promoted IPM principles but left the problem-solving and decision-making tasks to farmers (consistent with the AKS perspective) were judged to possess more understanding of pest monitoring and greater self-confidence to implement IPM programmes. These farmers used less pesticides and were more targeted in their pest control than their extension-led counterparts. Field school trained farmers evidenced higher yields with less variability culminating in higher sustained returns in the seasons following training.

Leeuwis (1993) studied communication technologies in the Dutch horticultural and dairy sectors. His case studies of 2 programmes to develop databases and

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Technology. 23rd and 24th November 1989, Wageningen, The Netherlands, Wageningen Agricultural University, Dept of Extension Science.

comparative analysis packages for farmers concluded that there was a lack of correspondence between the models implicitly incorporated into communication technology (CT) designs (by engineers), and the actual models used in a farming context. His findings are therefore consistent with Weick (1995) as discussed in section 2.4. Leeuwis contended that developers failed to appreciate the social dimensions of knowledge, information, rationality and communication in the design, development and use of CT. He found CT development to be a complex arena of negotiation among actors who at times compete and at other times cooperate depending on historical experience, resources, beliefs and goals. Leeuwis viewed CT development as a social process of learning. In this learning context, he suggested that a SSM approach may at times include too many actors with widely divergent goals that hinder development work in the early stages of design. Again, similar to Weick, Leeuwis warned that using formal planning procedures may obstruct innovation and progress in CT development by restraining the incorporation of learning experiences into the development process. Leeuwis offered a learning methodology for CT development that clarifies the responsibilities and incorporates the learning experiences of the various actors in the development process.

Coutts (1994) reviewed the development and implementation of a formal extension strategy statement by the Queensland (Australia) Department of Primary Industries. He investigated the power relations and extension objectives from an AKS perspective. Coutts study concluded the formal extension policy was used to pre-empt changes in the extension function judged by some actors to be inappropriate for the Queensland situation. Formal policy enabled some actors to make claims on resources and ensure the continuance of extension functions to the public. This Coutts referred to as the use of policy to strategically renegotiate the public role of extension. He considered formal policy was less successful at altering the interface between clients and extension officers. This second aspect of policy was termed the collective level. Coutts offered the policy development process a framework for developing policy content. This framework sets a societal rationale for extension against pre-determined physical performance objectives; identifies enabling conditions of resources, processes and structures; and identifies constraining conditions of political and social imperatives. These objectives and conditions are negotiated simultaneously at strategic (by management) and collective (by extension officers) levels. Coutts contended discontinuities, or problems of alignment occurred when feedback between levels was found wanting.

A current substantive domain of AKS receiving considerable theoretical development is natural resource management. Röling (1994)conceptualised the *platform* as a way of attaining collective action on issues relating to environmental management.

> *'Therefore, environmental management involves 'collective agency' (the capacity to make a difference) at a platform of decision making which includes all stakeholders. Sustainable natural resource management, therefore, requires a* ***coupled system*** *between:*
>
> > *a 'hard'* ***agroecosystem*** *constructed according to biophysical science and managed on the basis of instrumental reasoning; and*
> > *a 'soft'* ***platform*** *constructed according to social insight and managed on the basis of strategic and communicative reasoning.*

> *Sustainability can be considered as the emergent property of the coupled system.'* (Röling (1994, p.285).

This concept of a decision-making platform dealing with coupled systems was useful in a study of farmer learning (Hamilton, 1995). In this Queensland study, farmers' fallow management methods were developed using a participatory action learning approach. Monitoring and gaming tools were developed for the farmers to collectively learn about their methods in a field context. The use of these tools within a learning activity framework provided a powerful stimulus to change in farming methods. The combination of group learning using learning tools like rainfall simulators, soil corers and the software package *Fallow Management Game* enabled farmer actions, observations and reflections to be worked out in group debate. Hamilton suggested under conditions of complexity science has a role to facilitate learning.

Engel (1995) pursued a pragmatic advance of the AKS approach by developing a methodology for participatory analysis of knowledge systems. Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) is 'a participatory action-research methodology for studying innovation-related problem situations and for designing possible courses of action' (Engel, 1995, p.5). A RAAKS analysis involves a team of researchers, using multiple data gathering and analytic techniques, to construct 'windows' of insight into the AKS. The research team follows a case study research strategy to rapidly (3 to 15 days) gather data about a wide range of 'actors' and interactive mechanisms operating in the AKS. Data is usually analysed as a team involving some members who actively operate in the AKS under study.

The conceptual basis for designing RAAKS was formulated as 'Networking as Innovative Practice'.

> *'I propose to speak of 'networking for innovation' **only if** each of the following three appreciations has been recognised by those actors involved: (1) the existence of a relative but critical deprivation of experiences, knowledge and/or information which hampers individual competent performance; (2) the need to jointly gain a more comprehensive and more effective understanding of a common problem or concern; (3) the wish to work out alternative development proposals and, possibly, argue these in view of alternative proposals by other actors. All three reflect a genuine concern to improve the quality and impact of individual and/or joint performances. Networking for innovation is done to break through relative isolation and to facilitate social learning processes amongst actors engaged in different social practices.'* (Engel, 1995, p.156).

Engel reviewed over 50 case studies spanning 15 countries and concluded social organisation of innovation emerges as a result of networking activity. He refers to 4 emergent forms occurring in *theatres of innovation*, viz.:

- convergence: actors focus debate and strategy thereby reducing the range of innovative scenarios;
- resource coalitions: whereby actors pool resources in joint performance;
- communication networks: actors purposive construction of joint learning experiences
- innovative configuration: durable relationships for innovation emerge from some strategic consensus about the combination of the above emergent forms.

The RAAKS methodology was offered as an instrument to assist actors to organise themselves work cooperatively and facilitate complex innovative processes.

In summary, the AKS perspective provides this research with a systems orientation that emphasises actors operating in an institutional context of organisations that develop and use technologies purposively. By using a systems approach explicit account is made of the actors, their beliefs and goals and the interactions among actors that participate in the social construction of knowledge. However, the AKS perspective also constrains the analysis of technology management to issues of knowledge. Perhaps surprisingly by restricting analyses of technology management to primarily knowledge issues has significant implications for the investigation of learning. For example, the AKS perspective represents extensionists as dealing in knowledge products, yet their role in theatres of innovation may extend beyond developing and trading in IPR. Of more concern is the separation of instrumental, strategic and communicative rationalities. The activities of actors combine all three rationalities at any point in time. However, the AKS perspective, following Habermas, has placed the normative overtones embodied communicative rationality into an operative realm of human cognitions, thereby confusing aspects of human activity. Furthermore, the AKS perspective, using the SSM, presumes a common problem to exist prior to action being taken by a collectivity of actors. Yet an adequate theory explaining the activities of actors would account for the emergence of problems in the theatre of innovations. What is required is an improved perspective of the activities of actors in theatres of innovation as a means of advancing the AKS perspective in the context of a free market science system. A recently development in the social studies of science literature may offer some insight into the way actors perform activities with respect to technology management. To this end discussion now turns to the Interplay Model.

5.0 The Interplay Model

Concurrent with the development of AKS has been the recent emphasis on the notion of science as practice (Pickering, 1991). Practice refers to human action on the natural (hard system) and social (soft system) world. The need for an improved understanding of practice has also been recognised in business studies. Solomon (1992) claimed that apart from the patronising attitude of academics, it was the inherent inadequacies of theories, applied in business contexts, that resulted in their failure to inform the business manager - a failure to appreciate the practical world of the manager (see Box 2.2).

Constructivist literature views the research laboratory with a life of its own (Knorr-Cetina, 1981, 1992; Latour, 1987). Science is portrayed as a practice which ought to be analysed in terms of what they do - the activities they perform as routines activities in the daily life of a scientist. The activities of scientists are more correctly described in terms of the construction of phenomena in an artificial micro-world, rather than making independent observations of a natural world. The universality of science is therefore a construction, and a more realistic description has the outside world

adapting to the laboratory to permit the exchange of knowledge between science and commerce.

Box 2.2 The Need for a Theory of Practice

"Such theorising is, however, irrelevant to the workaday world of business and utterly inaccessible to the people for whom business ethics is not merely a subject of study but is (or will be) a way of life - students, executives, and corporations. Here, especially, the practical problem comes back to haunt us; how do these grand theories of property rights and distribution mechanisms, these visionary pronouncements on the current economy apply to people on the job? Of course, one could argue that this is the case in any science, and not just in the sciences either. The hard part of any academic teaching is taking very sophisticated theoretical material and watering it down for the hoi poloi or, more modestly, making it accessible in terminology that is not over simplified. But quite apart from the offensive patronising attitude presumed by this view, especially in the so-called liberal arts, it is inadequate for a more theoretical reason as well. The grand theories of the philosophy of economics, however intriguing they may be in their own right, are not adequate for business ethics, and for many of the same reasons that the classic theories of Kant, Locke, and Mill are inadequate. The theories themselves are incomplete, oblivious to the concrete business context and indifferent to the very particular roles that people play in business. Their inaccessibility or inapplicability to the ordinary manager in the office or on the shop floor is not just a pragmatic problem but a failure of theory as well. What we need in business ethics is a ***theory of practice*** *, an account of business as a fully human activity in which ethics provides not just an abstract set of principles or side-constraints or an occasional Sunday school reminder but the very framework of business activity. The heart of such a theory will not be a mathematical model but a down-to-earth, matter-of-fact account of the values that do and should govern business and business enterprises by way of motivating the people who actually live and work in business."* (Solomon, 1992, p99)

The issue of technology management in an agricultural context has also been recently addressed in the practice literature (Gremmen, 1993; Richards, 1993). Gremmen defined a practice as a social domain of action. He subsequently (1995) elaborated on this definition, to define a practice as a sequence of activities performed as a way of doing. This immediately raises the question, 'doing what?' Gremmen's response is that in answering the 'what,' an emergent property of a practice would become defined - the problem definition is worked out in the doing. Changes in practice derive primarily from internal achievements within the practice. External influences will speed or slow the rate of indigenous improvement in a practice, primarily as interactive experiences operate among practices.

Three levels of analysis apply to a practice (see Figure 2.2).

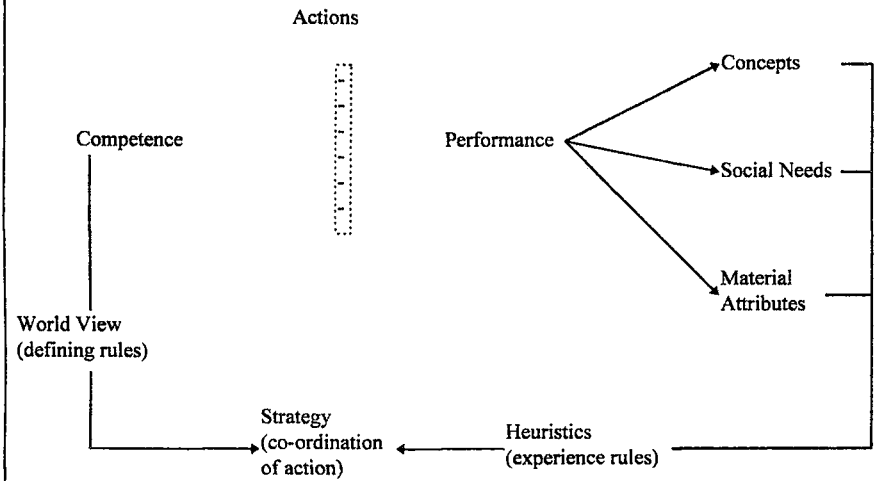


Figure 2.2 The Practice Concept

(Source: Gremmen, 1995)

At the first level a practice is visible by its activities, which are taken as the central unit of analysis (not knowledge). At the second level, activities are analysed in terms of competent performance. The competence is in the practice and not directly visible, except through the performance of the practitioners. Competence is the capability of practitioners to judge one anothers' performances - practitioners have a capacity to look over each others shoulders as it were and assess achievements in practice. This performance is expressed as the building of new concepts, the practice delivery to social needs, and/or the production of hardware[12]. A third level depicts the practice learning from its performance feedbacks to modify the heuristics that are used in combination with the practice view of the world to construct strategy. A strategy is a coordination of activities towards emerging problem definitions.

Practices operate to rules that correspond to the analytical levels of activities. Defining rules (rules of the game) specify the boundary conditions to practice activities as conventions. For example, the legal system has institutionalised the way professional practices define themselves, and how a practice is defined by other practices in society. At the third level, experience rules (rules of play) evolve as a consequence of activities performed consistent with the conventions of a practice. Gremmen explored this level in detail to explain the dimensions of competence in practice. His analyses enabled him to partially *get inside* a practice and contemplate the way practitioners work through errors in practice. Errors occur when practitioners violate rules of definition and experience. Definition and experience rules are

[12] Gremmen's use of competence in practice corresponds with the philosophic treatment of the subjective first person: the most fundamental event (action/experience) which cannot be fully accounted for by all third person (including scientific) observations of the subjective first person.

combined to form an algorithm[13] that specifies the correct sequence for the activities of a practice.

Take, for example, the movement of stock on waterlogged pastures. A sequence of activities precede the moment of decision and action (eg. a shortage of feed may shorten rotations). Many actions will follow as a consequence of moving stock - damaged pastures will reduce the options for stock movement, and either extra expenditure on supplements will be required or cow condition will suffer. These consequences have further long term consequences, and so on. For simplicity the example refers to practice as an individual entity. However, it is Gremmen's representation of practices at interplay that is of most interest to managing technology.

5.1 The Interplay model and the Emergence of Practice

Gremmen (1993) uses a model of practice interplay (ongoing interaction) to explain the emergence and development of practices. As will become evident, the interplay model is both the most relevant aspect of Gremmen's work to issues of technology management, and yet the most obscure in terms of conceptual development. When technical and scientific practices interact, changes occur in both practices yet each retains its own identity. Science and technology enmesh in a symbolic relationship (like performers in a play) when exchanges are mutually beneficial. The conditions of the relationship encourages the specialisation of labour, the anticipation of the next steps, and the opportunity to trace changes in relations[14]. When a scientific practice changes the defining rules of a technical practice it gives rise to a new science based technical practice, which in turn presents new opportunities for the interplay between technical and scientific practice, and between several technical practices. Interplay between practices may change experience rules, but will above all change the defining rules of each practice. Practices evolve because practitioners reflect on their actions, a form of '*indigenous rationalisation*' (Gremmen, 1993 p.115).

> *'The central claim of the interplay model is that improvement is primarily an internal achievement of practices themselves. External influences can speed up or slow down the indigenous improvement of a practice'* (Gremmen, 1993 p. 159)

Though competence is an *internal* attribute of a practice, the change in competent performance is activated through the interplaying of practices. A practice therefore exists in a milieu of practices, being dependent on these for growth and reproductive

[13] This term may cause some readers to think in terms of cybernetics and the reduction of human behaviour to a computer routine. On the contrary, following on from footnote 9, the first person experience is by definition a self awareness, brought on by some disclosure situation that, 'at the moment of decision we know ourselves active in a way that transcend all scientific accounts - the alternative includes the logical blunder of objectifying the subject.' (Hamilton, 1967, p.68)

[14] This aspect of Gremmen's analysis of actions and interplay is consistent with A.N. Whitehead's process philosophy which holds that entities (the basic units of existence - events that occupy an indivisible epoch of time) are defined through becoming, and by active prehension of experiences, '*How an entity becomes constitutes what that actual entity is: so that the two descriptions of an actual entity are not independent. Its 'being' is constituted by its 'becoming'. This is the principle of process.*' (Whitehead, p.31). His second assumption is that everything is interdependent, everything affects or depends upon everything else: the past affects the present, and the past depends on the present becoming.

opportunities. Practices are not self sustaining, but their adaptation is primarily self determined. We can now use Gremmen to investigate a paradox of dependence in the evolving practice.

So far this discussion of the interplay model has described practice as an entity that changes as a consequence of relationships with other practices. This can obfuscate the distinction between actors and practices. Gremmen does not explicitly address this issue, but some clarification of the actor and practice component of the model is necessary to make use of the model when using the AKS perspective. Systems theory offers some insight to the dimensions of the problem. Any practice has a hard systems dimension and a soft systems dimension. When chemistry and biology interplay they share substantive concerns that pertain to the hard systems dimension of practice. The objects of study, tools of practice, and the tangible activities of the practitioners make up the components of this hard system. The concurrent soft system dimension of practice has the practitioners performing the theatrical play routines in debate and negotiation that goes towards the building of defining and experience rules that make up *normal* practice. A new practice like biochemistry emerges as the components of both the hard and the soft systems interact when chemistry and biology interplay. Gremmen prefers to view practice as a whole, rather than distinguish between hard and soft system dimensions, as evidenced below.

Gremmen (1993) and Fujimura (1991) ask, '*how do different practices, with different methodological and substantive concerns succeed in co-operating?*' By applying the interplay model to this problem, Gremmen claims that practices need to link their experience rules to perform collective activities and share a common competent performance. Interfaces, referring to the means by which interplay is effected, consist of multiple intersections of practices. An interface can be a mutually shared aspect of competent performance between practices (connectible); the combining of several connectibles to share all aspects of a competent performance while retaining separable practices (joint performance); or the emerge of a broker practice (a new practice).

External stimuli (e.g. demands by clients), or internal discontent with performance (e.g. frequent serious errors) may prompt practitioners to develop a capability to share aspects of their competence with others - the way they code, conceptualise or set targets. It is the aspects of competence that connect the practices and enable them to successfully adapt and evolve. The perspectives discussed previously in this chapter limited their analyses to the types of performances that actors used in joint activity - competence was not investigated.

Joint performance emerges when many connectibles are used to augment normal practice. A joint performance does not exist as a regular part of a practice. Joint performances are typical of situations involving the exchange of practitioners between practices (e.g. mathematicians working on ecological issues). Managers of multi-disciplined project teams require an appreciation of the many connectibles necessary to achieve a successful joint performance.

If the interplay model is the most relevant contribution of Gremmen's work to technology management, it is the concept of a Broker Practice that is the most

significant aspect of that model. Broker practice is the most sophisticated interface in Gremmen's typology of practice interfaces. A broker practice generates a core competent performance that has an existence of its own linking science and technical practice. Gremmen's analysis of science and technology is at a relatively high level - for example he refers to agricultural science (see below) as an example of a broker practice. Broker practices initially have a precarious existence, requiring practitioners to mobilise interests and resources to common problem-solving approaches. Continuous and extended interplay among practices will evolve a broker practice with its own body of theory and methodological resources.

For a broker practice to mediate between practices its practitioners must do research. Broker practices are practical sciences that explain how new functional objects come into existence. As practical sciences they bring about events and processes that attempt to achieve desirable outcomes for the broker practice and its clients. Broker practices fulfil a number of roles in the interplay model. They make the results of natural or technical science fit for use in technical practice. Science results are transformed into competent performance in technical practice. Technical practice can use practical science to springboard sense-making in new situations (Weick, 1995).

This overview of Gremmen's Broker Practice concept does not distinguish between the hard and soft system dimensions of practice. Consequently it may appear that a claim is being made that the hard system dimension of practice *links* between science and technical practice. Yet how could a computer network *link* without practitioners? Gremmen views the tools, activities (by practitioners) and knowledge resources of a practice as a unity. His primary concern is to explain the evolution of new practice - either a Broker Practice will emerge to link existing practices, or a new practice will evolve as a consequence of the interplay among existing practices, irrespective of the presence of a Broker Practice. A Broker Practice possesses unique tools, routines and knowledge resources to perform competently in linking existing practices.

5.2 Agricultural Science

Agricultural science studies life processes relevant to agricultural practices. Social needs provide the purpose for these studies - to align human systems with natural systems to satisfy the requirements of both. Agricultural science concepts have a dual epistemological status - they refer to competent performance in technical practice and in natural science. The similarity between phenomena studied in agricultural science, and those manipulated in technical practice eases the interplay between scientific and technical practice. Agricultural science cannot rely on closed theories, rather it systematically varies parameters using incomplete and often informal knowledge to understand and modify nature. Research methods include trial and error experiments (allied to technical practice, with no *a priori* explanations) that accumulate incremental improvements in practice.

In agricultural science the framing of problems and roles is usually not explored explicitly - the construction of reality is not questioned, therefore researchers are often not aware of alternative ways to frame problems. It is more likely human research

methodologies, or practical modelling tools are introduced as adjuncts to farm experimentation programmes under trial and error. As agricultural research converges on an increasing number of complex systems problems like sustainable resource management issues, there is increasing demand for a systematic process that frames problems, develops theory or link causal relations in natural systems. A Broker Practice may facilitate the alignment of multiple methodologies in coherent framework for investigating such complex systemic problems.

The Interplay Model contributes an understanding about the emergence of new practice. Furthermore, it sensitises observers using an AKS perspective to analyse the performance of Broker Practice and thereby determine the model's significance to informing privatised science systems. Empirical studies of practice performance ought to resolve an apparent paradox in Gremmen's analyses, viz. the competence of practice is in the performance (internally derived), while the motive force for change in practice is found at the practice interface. Practices are defined by the tension between internal competence building, and an external interplay with other practices.

6.0 Conclusion

This chapter has examined insights developed by diverse disciplines on technology and its management. The coverage of several knowledge domains was considered essential for developing an appreciation of agricultural technology in relation to organisations working together. It can be argued that the issue of uncertainty[15] is a central concern to those actors that develop and use technology. In the context of this chapter discussion moved from an opening position of uncertainty posing a problem of control to the actors involved in technology management. As issues of market demand, contemporary culture and competitive actions were explored it was found that an understanding of collaborative actions among organisations was poorly developed. Recent work has argued that collaboration in the context of technology management is a competency in its own right. The organisational heuristics, behaviour of mediating actors and negotiation processes involved in collaborative relationships required further understanding of the dynamic patterns of activity in relation to technology. Weick's notion of coupled systems provided a turning point in this chapter, whereby uncertainty was viewed as an opportunity for interaction, rather than a problem of control. The way rules and the double interact are combined to negotiate some compromise between ambiguity and organisational stability suggests collaboration is not a planned outcome that blends knowledge and experience in the *right* proportions. Rather, collaboration emerges from unplanned actions when a sufficient culture of trust encourages further commitment by actors to share resources and act together. A positive but countervailing activity to this trust is the

[15] See for example Wubben, 1993 For an economic history of markets, uncertainty and decision making. Wubben refers to Knight's definition of uncertainty as, '... the fact of ignorance and necessity of acting upon opinion rather than knowledge', as distinct from risk, the latter refering to situations where measurement is possible, particularly the use of probability distributions. 'The profitability of producing and selling cans of onion soup is at most risky, as is the waiting time at traffic lights. But the profitability of an investment in a new generation of micro-processors is highly uncertain, as is the price of Brent-oil 10 years hence.' (p.6).

promulgation of doubts by senior managers among collaborating workers to prompt competent judgment in the management situation.

An agricultural interlude was required to prepare the way for the investigation of knowledge systems and the theory of practice. The collaboration position developed in the preceding discussion was a convenient point of entry to literature on agricultural technology. Farming system research, and PTD in particular, emphasized the importance of user involvement in technology development stages. There was a call to appreciate the local knowledge of farmers. A diversity of participatory approaches have been generated in recent years, indicating the importance of specificity of programme design to the problem context and social construction of knowledge in each situation.

The AKS perspective appreciates the social world of constructed knowledge, with all its complexity and change. This appreciation stems from the SSM origins of AKS, and the notion of communicative rationality developed by Habermas. Actors may not operate harmoniously in a theatre of innovation, therefore AKS provides a diagnostic frame to explore the development and use of knowledge by complementary actors. Recent methodological developments like RAAKS rely heavily on SSM to organize actor inquiry as a systemic learning process. Learning is a key component of the AKS perspective for negotiating collective action towards the achievement of innovative outcomes on complex issues like IPM, CT, sustainable agriculture and extension policy.

The Interplay Model is the final perspective woven into this conceptual framework of technology management. Whereas AKS appreciates the knowledge domain of technology, the Interplay Model appreciates the domain of activities. The question arises, are AKS and Interplay complementary or substitutionary perspectives of technology management? Both perspectives hold that knowledge is socially constructed. The Interplay Model holds that knowledge is constructed by actors who take action and then make sense of their world as a consequence of their actions. Practice is treated as a domain of activities, often recognised by people in general, to possess specialised tools, methods and knowledge that are integrated in the performance of work. The Interplay Model deals specifically with links between technical and scientific practices. The evolution of new practice is explained as a sharing of rules from both scientific and technical practice to create a unique practice capable of indigenous rationalisation. Two adaptations of the Interplay Model would be required to align AKS and Practice perspectives, viz.:

- Recognise professional practice as the domain of activity that most concerns the theatre of innovation, rather than distinguish scientific and technical practice.
- Resolve an apparent dichotomy between indigenous rationalisation, and the motivation for change from interplay experience.

Weick provides a clue to aligning the AKS perspective and the Interplay Model. Coupled systems appreciate both rules for action and systems conventions. It was suggested that introducing SSM terminology to the Interplay Model may assist efforts to integrate perspectives and thereby extend understanding of the conditions and processes that foster harmony in a theatre of innovation. This issue of aligning perspectives to extend understanding of technology management will be developed

further in chapter seven. It is now necessary to introduce the empirical context that is used to investigate the alignment of perspectives for informing programme strategy in a privatised R&D economy.

Chapter Three

The New Zealand Context: a changing continuity in the Dairy Sector

'NZ Farming is still not completely out of the problems of the last decade, but it is well on its way. Farmers have emerged as a stronger, more independent and more flexible group of business people ... Without the distortion of protection and assistance, price signals are now much clearer. NZ farmers are ready to respond to the vagaries of the world food markets' (Bywater, cited in Cloke, 1996, p324.)

'At a time when NZ as a nation is galvanised by success in international rugby and America's Cup yachting, it is perhaps understandable that the same independent proud spirit should pervade accounts which are offered to the outside world about the traditional economic pride and joy of NZ - its farming.' (Cloke, 1996, p.327)

1.0 Introduction

In this chapter the reforms in the national economy are outlined in terms of the conditions that fostered a change in economic policy that had implications for the dairy sector. An introduction to the technological heritage of NZ pasture based farming leads into a discussion of the impact of the reforms on the NZ science and dairy marketing systems. A changing continuity in the national economy and the impact of these changes on theatres of innovation provides the context for discussing NZ dairy farming and the contemporary challenges confronting the dairy sector. This chapter concludes with a problem statement developed as a response to theoretical and contextual issues identified in this and the previous chapter.

2.0 Change in the National Economy

2.1 Conditions for change

The NZ farming sector contributes significantly to the nation's overall economic output. Agriculturally based products contribute 60% of NZ's total merchandised exports (SONZA, 1995). The farming sector averaged a 6% contribution to the GDP over the past 5 years (see Table 3.1), derived from half the total agricultural output.

year end 31 March	1990	1991	1992	1993	1994	1995
Sheep & Beef	3,304	3,093	3,038	3,291	3,480	3,433
Dairy	2,166	1,641	2,203	2,484	2,569	2,462
Other farming	2,138	2,159	2,282	2,354	2,258	2,387
Other	1,676	1,598	1,577	1,840	2,170	1,834
Farm Sector as % contribution GDP	**6.4**	**5.3**	**5.9**	**6.4**	**6.4**	**5.7**

(Source: SONZA, 1995)

Table 3.1 Gross Farm Sector Production ($ million)

Export receipts from NZ agricultural outputs benefited from both world wars and the Korean war. Commodity price booms associated with these wars funded an internationally high standard of living that peaked in the 1950's and 1960's. New Zealand, as a member of the British Commonwealth, enjoyed privileged access to UK consumers. New Zealanders adopted affluent purchasing behaviour based on the temporary wealth generated by high commodity prices. The combined effects of this consumer behaviour, with the crude oil price rises during the 1970's, Britain's entry to the EU, and extensive protection of the local primary and manufacturing industries, eroded the strength of the NZ economy. In 1960 NZ was debt free and her citizens enjoyed a standard of living ranked in the top 3 of OECD nations (Rayner, 1990). This position steadily declined as economic policies protected farm incomes from declining export prices; regulated the labour market; and invested heavily in projects designed to reduce national dependence on expensive energy imports.

In 1984 the nation confronted an economic crisis with national debt servicing costs rising to 50% of GDP (Rayner, 1990).

> *The costs of NZ's protectionist policy were originally masked by the commodity boom of the 1950's. As this evaporated, so the economic performance of the country declined. This is not surprising, given that protection removed the need for domestic manufacturing to keep up with improvements in technology overseas and that agricultural protection overseas prevented NZ from exploiting its natural advantage in the production of temperate pastoral commodities.'* (ibid., p19).

Radical economic policies were therefore implemented by the 1984 Labour Government, a party that traditionally promoted socialist values. This Labour Government introduced free market policies, that have to date received continued support by successive governments, to restructure the public sector, and deregulate financial and labour markets. These policies transformed the welfare, health, education, and science systems in NZ.

Box 3.1 The Rationale for Public Sector Reforms in New Zealand

'The underlying theoretical rationale for corporatisation was relatively clear cut: it was felt that efficiency could be improved by approximating a private sector model. As argued above, this drew heavily on the literature on property rights and principal-agency theory. In particular, it was argued that managers' responsibilities and incentives had to be redefined so as to bring them into line with the principal's (i.e. the Crown's) objectives.

In line with this theoretical approach, Deane identifies four key objectives of the corporatisation process in New Zealand:

- State enterprises managers are meant to have a single clear *objective*, the maximisation of commercial performance. This is intended to provide a direct and unambiguous focus, facilitate monitoring, improve accountability, and prevent inconsistent political objectives.
- State enterprise boards of directors are to have the *authority* to make the decisions necessary to meet these objectives. They are responsible for major investment, recruitment, and other strategic decisions. Ministers retain overall responsibility for the firm's performance but should not be more closely involved.
- Management performance should be closely monitored against the objectives achieved, by ministers, the Treasury providing advice; some private sector monitoring also occurs.
- There is an improved system of *managerial rewards and sanctions* to reinforce the incentives for performance. Salaries and employment should be linked to performance.' ' (Duncan and Bollard, 1992, pp14-5)

The transformation of NZ public sector services followed the guidance of free market protagonists (see Box 3.1). Government policy sought to improve public sector efficiency by following the private sector model to inform transaction activities.

2.2 Impact of reforms on agriculture

In line with free market reforms government policy was to reduce agricultural subsidies. NZ followed an opposing trend to most OECD nations by reducing subsidies on export products from the mid 1980's (see Figure 3.1). Japan and the European Union continue to lead the world in the subsidisation of their agriculture. While Canada and the USA have reduced subsidises, NZ went further at a faster rate than any other industrialised nation. The impact of reforms on the farming sector was extensive (see Table 3.2).

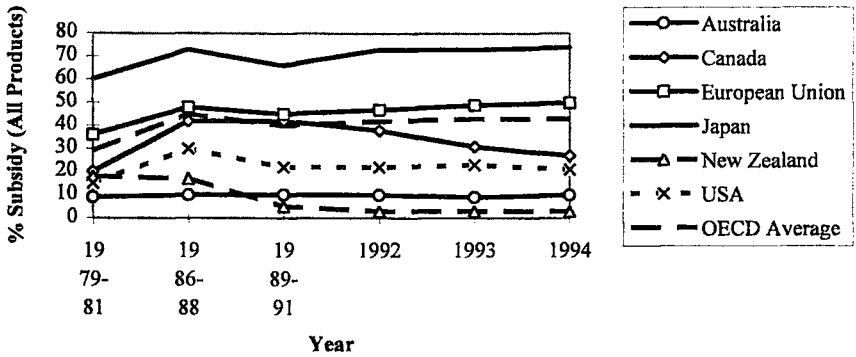


Figure 3.1 Producer Subsidy Equivalents

(Source: SONZA, 1995)

Subsidisation provided assistance to outputs and inputs in pastoral agriculture. Output subsidies attempted to smooth commodity price fluctuations and thereby improve policy planning while reducing the risk to farmers that contributed to the nation's export receipts. Output assistance was effectively removed by 1992, along with most of the input subsidies including fertiliser subsidies and special development loan schemes (see Table 3.2). By 1992 public expenditure on assistance to pastoral agriculture declined to one sixth of 1984 values. Expenditure on advisory services steadily declined until the service was privatised in 1994.

Expenditure on agricultural research was the only agricultural vote item increasing over this period. The rationale for this apparent inconsistency, relative to declining expenditure in other areas of agriculture, relates to a policy perspective on knowledge and its role in society. Government viewed itself responsible for the advance of basic scientific knowledge, while agricultural sectors were required to take more responsibility for the extension and use of applied scientific knowledge (Min. Sci. Task Gp., 1991). Following this rationale, policy-makers legitimately increased funding for research, and argued for a complementary increase in R&D investment from the agricultural sectors.

Table 3.2 Levels of Assistance to NZ Pastoral Agriculture ($ million)

	1980-84	1985-90	1992	1993	1994	1995
Assistance on Outputs	271	104	9	5	4	4
Assistance on Inputs	73	28	12	11	1	2
Assistance to Value Added Factors						
Advisory	10	13	2	1	0	0
Research	**38**	**54**	**56**	**58**	**61**	**61**
Other	381	483	47	40	38	39
Total V.A. Assistance	429	550	105	99	99	100
Total Gross Assistance	773	681	126	115	104	106
less: Excess costs on Pastoral Agriculture	359	335	196	179	147	139
***equals:* Net Assistance to Pastoral Agriculture**	**414**	**346**	**-69**[1]	**-64**	**-53**	**-33**
Unassisted Net Output in Pastoral Agriculture	1,007	1,728	1,978	2,184	2,372	2,408
Effective Rate of Assist. to Pastoral Agri.	41	20	-3	-3	-2	-1

(Source: SONZA, 1995)

In the next section the NZ dairy sector is introduced to extend this contextual framework. In particular the technological origins of the sector are outlined before describing the contemporary situation, in terms of dairy production systems and sector infrastructure. Subsequent discussion links the influence of the reforms on farming system research and extension activities and consequent challenges confronting the dairy sector. The issues emerging from this discussion are developed further in section 4.0 as a problem of alignment between activities performed in the new science system and those performed in the sector marketing channel.

3.0 Change in Dairy Farming

3.1 The technological origins of NZ pasture based farming

New Zealand agriculture emerged from the trial and error modification of the landscape in recent history.

> *'The rate of forest clearance increased sharply with European settlement and the half-century from 1850 to 1900 was a time of one of the most rapid changes to the landscape of any nation ... New Zealand's history of landuse admirably illustrates the growth of any biological community. A land resource was recognised and exploited; limitations to use were often perceived only dimly and many development attempts failed; growth barriers were broken through innovation (technology or the development of alternative landuse systems); crises, either ecological or economic, were faced and successful changes in direction sometimes resulted. Gradually, however, exploitation was transformed into a permanent agriculture, and a new landscape emerged in the cleared*

[1] Derived from receipts on service from government to producers

lowlands - a blending of old world mixed farming with new world agricultural innovation. The eventual result was the traditional permanent grassland system for which NZ is renowned.' (DSIR, 1980, p11).

New Zealand has been populated by waves of migrants from diverse ethnic origins over several centuries. Early settlements (ca 1400on) by Polynesians were in response to over population and food shortages in the Pacific islands. Later settlements (ca 1800on) by Europeans were consistent with the colonial policies of western nations. New Zealand's bicultural society (Maori and English) in the mid 1800's became multi-cultural in the late 1800's with Chinese and Slavic migrants. These settlements were motivated by an expectation of wealth from the land: food for Polynesians; farms and businesses for the Europeans; gold for the Chinese; and kauri gum for the Slavics. Each period of settlement wrought changes in the NZ landscape such that pasture and arable farming are now the dominant landuse (see Table 3.3).

Table 3.3 New Zealand Land Cover (1990/1)

	Hectares (million)	%
Total forest	7.5	28
comprising: natural	6.2	23
planted production forest	1.3	5
Total pasture and arable	13.9	51
Other land	5.6	21
Total land area	27.0	100

(Source: SONZA, 1995)

Pasture based farming of sheep and beef, and more recently deer, has dominated hill country farming systems. Fertile accessible flat lands farm pasture fed dairy herds. Horticulture is confined to regions with a favourable combination of climates and soils. radiata pine forests generally occupy areas that are considered to be economically marginal for pastoral farming. Over 50% of New Zealand is now covered in pastoral farming (see Table 3.3), up from 35% at the turn of the century. The expansion of pastoral farming was achieved at the expense of natural forest cover.

McLauchlan (1981, p.99) summarised the development of pastoral agriculture in NZ:

'Pastoral farming began in NZ as soon as the first Pakeha settlers arrived with stock to run. They found the greatest asset was the climate - moderate temperatures and a high rainfall distributed relatively evenly through the year. The first problems were the clearing of the land and the construction of roads and railways; and then scientific research and the dissemination of accumulating knowledge led to a period of rapid advancement in livestock farming between the two great wars. By 1920 the cow and sheep had become undisputed kings of the countryside, swathed as it was in lush green pasture. The period from 1920 to 1980 will almost certainly been seen in the context of history as the rise and peaking of pastoral farming in NZ.'

By European standards, NZ's agriculture is a recent phenomenon. Current agriculture stems from an historical mix of Government land development policies, international

market opportunities, and the use of innovations from farmers and scientists. Pastoral agriculture became the dominant landuse as early as the 1920's and now accounts for the majority of titled landholding in NZ. A series of prominent activities represented as a complex of organisations, individuals and international events, combined to mould the landscape and develop a NZ system of pasture based farming that is dependent on technological inputs to maintain or improve an internationally competitive productive performance (see Box 3.2).

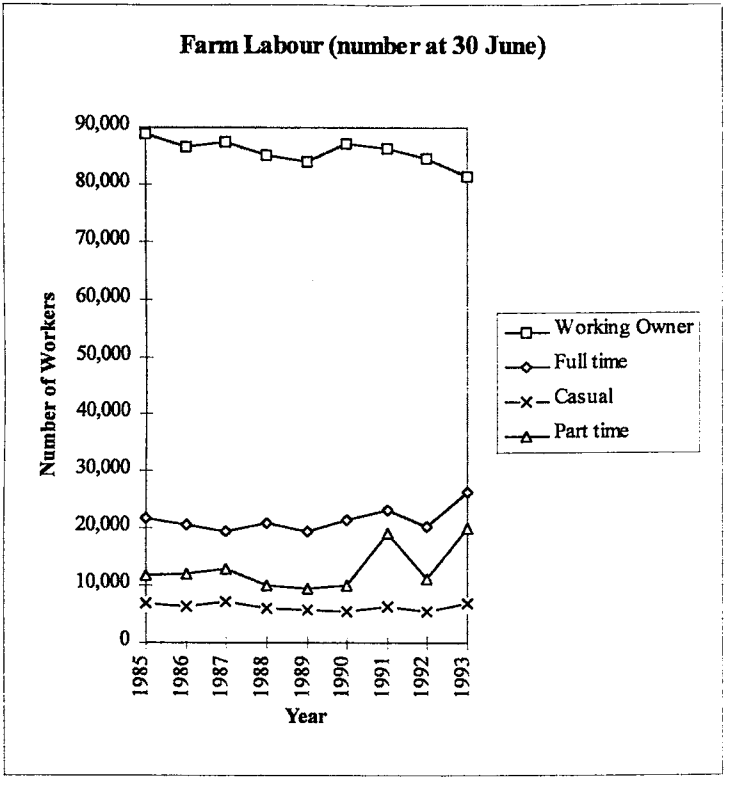
A series of technologies were involved in the development of pasture based farming in NZ including, among others: fencing; fertilisers; plant and animal breeding; refrigeration; and transportation technologies. Early exploitation gave way to extensive pastoralism, and later expansionism dependent on new technology. Science and technology played a prominent role in the intensification of agriculture from 1920 to 1980. Aerial topdressing and later electric fencing almost doubled the carrying capacity of many farms. By the early 1980's many farmers were searching for alternative enterprises to reduce dependence on the fluctuating fortunes in commodity markets. During these development phases agricultural science provided *decision rules* for landusers, as exemplified by Levy (1970, p.82):

> *'It is necessary to impress on every one likely to be concerned with the planning of an agricultural programme that farming is not a question of whim but of the alignment of agricultural practice to ecological conditions, governed first by climate and secondly by soil. Climate is subject to little or no influence by man, but soil conditions may be greatly modified where climate permits long periods of sustained growth. On these long-sustained growth periods permanent grass depends.'*

By 1985 almost 90,000 owners worked the land (see Figure 3.2). With the decline in farm incomes from 1985 to 1993 over 7,200 owners left employment in farming, replacing their contribution with full time employees (4,400) and casual workers (8,200). The restructuring of the farming working force impacted on rural communities, with declining school roles, reductions in merchandising and the provision of postal services (Campbell, 1994; Fairweather, 1992; Pawson & Scott, 1992).

Box 3.2 A Chronology of Critical Events in New Zealand Agriculture

1821	The first land in NZ is ploughed in Kerikeri, Bay of Islands
1831	The first farm in NZ is established at Waimate North by the Church Missionary Society
1850	Large-scale settlement begins, sheep are widely farmed, wool becomes an important export
1876	Passing of the Rabbit Nuisance Act
1878	Lincoln Agricultural College (later University) foundered, (Massey Agricultural University College foundered in 1928)
1870-1920	Grassland area increases by clearing native forest at a rate of approximately 120,000ha/year
1882	The first export of frozen meat from Dunedin - enables a shift from 'dry-stock' to 'wet-stock'
1884	The first Government Act to prevent introduced pests & diseases (Codling Moth Act).
1892	The formation of the Dept of Agriculture, and the beginning of farmer advisory services, quarantine regulations for livestock, plants and produce, and the introduction of cow testing for production to assist breeding selection
1909	The first cow testing association is formed
1910	Publication of the NZ Journal of Agriculture starts. Increasing demand for agricultural advisors to help farmers. Diseases of crops and livestock are controlled using pesticides. Topdressing of pastures using fertilisers becomes more common.
1920	Large farms are being subdivided: closer settlement & increased production. A notable increase in farm mechanisation: electric motors; farm tractors; and milking machines. Topdressing of pastures and herd recording to improve herds is widespread
1930	The development of superior strains of pasture plants and their assured supply to farmers by certification. Marked improvement in grazing management of livestock is achieved
1935	The discovery of cobalt deficiency in the volcanic soils of the North Island Central Plateau, causing 'bush sickness' opens large tracts of land for development into viable farms
1936	Plant Research Bureau (DSIR) opens in Palmerston North
1938	Facial eczema outbreak leads to establishment of animal disease division (MAF) in Ruakura
1939	Establishment of the Animal Research Division, (MAF), to co-ordinate departmental research into animal diseases, husbandry, breeding and nutrition
1940	Sire surveying & progeny selection to improve dairy cattle, later extended to sheep
1943-62	Ruakura Animal Research Station, under the management of McMeekan, becomes a world renowned pastoral research centre
1950	The application of fertilisers and seeds to unploughable hill country using aeroplanes; dropping of fencing materials for closer subdivision of improved pastures. More emphasis placed on the study of trace elements necessary in the nutrition of animals and plants. Large scale application of artificial breeding to dairy cattle.
1950-60	Commodity price boom, comparative wealth of NZ (c.f. OECD) reaches a peak.
1956	NZ hosts the Seventh International Grasslands Congress; Brougham publishes, 'A study in the rate of pasture growth.' in the Aust. Jnl. Agr. Res. - it will revolutionise scientific thinking on grazing management systems
1973	Britain enters the European Community and thereby reduces access to dairy and sheepmeat export markets for NZ
1973-84	The oil shock catalyses a dramatic decline in NZ economic performance; government overseas debt increases from 0 (1973) to 50% (1984) of GDP
1980	Kellogg Farm Management Unit established: initiates extensive promotion of computers in agriculture
1982	CER agreement establishes free trade between Australia and NZ
1978-90	Farm subsidies as guaranteed prices (SMP), producer board debt write-off, and fertiliser subsidies accumulate a total Government payout to farmers of $604m
1991	Resource Management Act affects every farmer in NZ, who are now required to vigilantly manage the natural resources under their farming stewardship
1985-1992	Privatisation of Government extension services and corporatisation of science organisations (DSIR and MAFTechnology) into Crown Research Institutes
1993	MAF release position statement on sustainable agriculture
1994	Ratification of GATT agreement (Uruguay), EU implement in 1995, threat of non-tariff trade barriers to NZ agricultural exports
1995	Settlement of tribal land claim with Tainui - first full and final settlement with a Maori tribe



(Source: SONZA, 1995)

Figure 3.2 Farm Labour (number at 30 June)

Change in the composition of the farm workforce did not make a significant difference to the area of grassland farmed in NZ over the period of the reforms (see Table 3.4). Nor did the reforms have a significant influence on the change in the number of grassland farms.

Table 3.4 Area of Occupied Land (000 hectares) and Number of Holdings

Landuse @ 30 June	1988	1989	1990	1991	1992	1993
Grassland, lucerne & tussock	13,911	13,819	13,624	13,540	13,517	13,769
Grain	189	192	189	175	180	176
Nursery, vegetable, fruit	89	90	88	90	90	94
Plantation of exotic trees	1,265	1,249	1,304	1,329	1,335	1,396
Other land on holdings	2,291	2,302	2,284	2,315	2,178	1,900
Total area of farms	17,746	17,653	17,489	17,450	17,300	17,336
Number of holdings	82,063	82,687	80,904	80,439	79,666	81,196

(Source: SONZA, 1995)

However, during the period 1985-1993, farmers responded to their declining fortunes by altering their fertiliser policies. The application of phosphatic fertilisers emerged as an essential component of the pastoral farming system in New Zealand through a combination of agricultural research and trial and error by farmers. An appreciation of farmers' beliefs about the impact of reduced applications of phosphatic fertiliser requires some background on the origins of scientific thought on pastoral farming. Levy (1970) considered A.H. Cockayne's philosophy and foresight made him, '*The father of scientific thought on grassland farming*'. Cockayne was the Director General of Agriculture in the 1930's. He envisaged a future for agriculture in New Zealand, dependent on technology and scientific discovery, that would transform the landscape and wealth of the nation (Cockayne, cited in Levy, 1970. pxxxix).

> *'The great development of recent years has been the transition of much of this type of country from dry stock to wet stock by veneering the surface with a film of phosphate irrespective of the virgin fertility, or lack of fertility, of the soil itself.... Following on the recognition that a rain-forest climate is synonymous with a high production grassland potential, an intensive type of grassland farming was evolved having for its objective the production and utilisation of milk producing pastures, for the cow, ewe, or sow - the essential elaborating machinery of our grass crop into butterfat and rapidly maturing meat. There were great potentialities of New Zealand increasing her grass crop and in improving the utilisation of this great crop by the adoption of standardisation that was based on critical interpretation of developing experiences, buttressed by investigation and research to enable the interpretation to be accurate.'*

The *veneer of phosphate* enabled subsequent workers like Sears, a pasture ecologist, to advocate pasture improvement through genetic improvement of plant material and soil fertility. Sears pushed for the protection of genetic gains captured in breeding programmes using seed certification during the 1930's (Sheath, *per. comm.*).

Farm systems research emerged with field experimentation for improved pasture performance and more recently pasture quality and modelling pasture and animal interactions (McCall, Sheath and Pleasants, 1994). Agricultural research in NZ is therefore depicted as a continuity of effort, from improving component performance to managing interactions in the farm system, towards improving the appreciation of the complexity and uncertainty that farmers confront in managing their farm systems. For example, the need to reduce superphosphate application while retaining the viability of farms provoked a search for alternative sources of phosphate and more emphasis on nutrient budgeting to more effectively cycle nutrients in the farm system. While superphosphate declined in use from the early 1980's, farmers adopted alternative sources of cheaper phosphate such as reactive phosphate rock from the early 1990's (SONZA, 1995).

The discussion above outlined technological developments pertaining to general grassland farming in NZ. While these developments were directly related to the emergence of the NZ dairy farm system and associated systems research and extension, subsequent discussion will concentrate on the unique features of the dairy sector.

3.2 The dairy production system and sector infrastructure

Dairy farmers own over 20% of all farms operating in New Zealand (see Table 3.5). Most farms are owned as husband and wife partnerships.

Table 3.5 Farm Business Owners by Farm Type (%) 1992

	Dairy	Sheep & Beef	Remainder	All Farms
Absentee	14	32	53	36
Working 1	28	36	22	29
2	46	28	23	30
3	7	2	1	3
4+	5	1	1	2
Total Farms	16,480	32,780	30,400	79,600

(Source: SONZA, 1995)

Dairy farmers, both male and female, tend to be younger than their colleagues farming mixed livestock or other enterprises (see Table 3.6). An ageing farm workforce is fuelling concerns among rural professionals and sociologists about the management of farm succession (Alexander, 1996; Fairweather, 1992; Pomeroy, 1993). Dairy farmers are better placed than their mixed livestock peers, with young farmers having a sharemilking tenure system to enter the sector. Sharemilking is credited with maintaining a steady stream of new entrants to the sector (Squire and Delhunty, 1986; Hutton, 1987). Young farmers can enter the sector with a limited capital base, acquire stock as a contribution to the assets of a dairy farm, and in return share in the profit performance of the farm. The sharemilker system enables new entrants to first purchase their herd, and later their farm. If no family successor is apparent, the system enables established farmers to avoid the physical demands of farming while retaining a professional interest in the management of their land. Hutton (1987) estimated 25% of all herds milked in New Zealand have been milked under a sharemilker agreement.

Table 3.6 Average Age of Farmers

	Females			Males		
	1981	1986	1991	1981	1986	1991
Dairy	37.0	38.2	39.9	40.7	40.9	41.8
Mixed Livestock	43.2	43.2	45.2	44.8	45.0	47.3
Others	43.0	41.8	46.8	45.8	44.2	48.6

(Source: SONZA, 1995)

The pastoral basis of New Zealand dairying generates a seasonal supply of milk for factory processing commencing in August, peaking in October/November and finishing in April/May. In recent years the number of suppliers has diminished as herd

size increases (Livestock Improvement, 1995). Herd numbers declined by 4,088 from 1974/75, to reach a low of 14,452 in 1991/92. In recent years the number of herds have increased to 14,649 (1994/95) as a result of the conversion of many sheep and beef farms to dairying. Milksolids production/cow is continually improving with more herd testing and cows serviced through artificial breeding techniques. Insemination records show a steady trend towards Holstein/Fresian stock, with a declining demand for Jersey genes. Real returns (Dec. 1993 base) have averaged $3.82/kg milksolids[2] since 1974/75 (max. = $4.64/kg; min. = $2.62/kg). Most herds (58%) are located in the northern half of the North Island. Regional variation is most distinct between North and South Island herds, the latter having larger farms with lower production per hectare.

Box 3.3 Dairy Sector Statistics (National Averages for 1994/95)

1. **herd size**: 193 cows (c.f. 112 cows in 1974/75)
2. **production**: 29,886 kg milkfat
3. **returns**: $5.95/kg
4. **area**: 80ha
5. **stocking rate**: 2.5 cows/ha.

(Source: Livestock Improvement, 1995)

By European standards herds are large (see Box 3.3) and production costs are low.

Sector infrastructure

The NZ dairy sector is extensively vertically integrated (see Figure 3.3). Farmers supply milk to co-operative dairy companies (owned by farmer shareholders) that process milk for export. All export sales are co-ordinated by the New Zealand Dairy Board (NZDB) as a *single desk* selling system. Total annual sales in the dairy sector total $5.0 billion, of which $3.5 billion are generated from export sales (NZDB Annual Report, 1995). The NZDB is the largest export company in New Zealand. In recent years the dairy sector has undergone extensive rationalisation as new food technologies demand considerable capital expenditure on modern plant and equipment.

> *'New Zealand milk processing sites, which have decreased from 229 to 24 since 1970, now process on average more milk per day than plants in any other country.'* (NZDE, Mar 1996, p,125)

Companies require access to large volumes of milk to fund and utilise new plant. Milk volumes have been secured through amalgamations or take-overs of competing

[2] The NZDB pays dairy companies for the export products they produce according to the market returns received for those products. The companies equate the returns receive from NZDB to a set return per kilogram of milk solids for seasonal suppliers, based on an A+B+C system: milkfat (A); protein (B); penalities for milk volume (C). Milkfat equates to milk solids at approximately: milkfat = 1.75(milk solids). For Waikato/South Auckland farmers these returns equated to an estimated disposable profit of 34c/kg milksolids (MAF, 1996). Payment systems for town suppliers (all year round production) varies with the company; 5% of national production goes to town supply.

processors. Recent dairy sector restructuring has empowered dairy companies to influence the quality of milk supplied through pricing mechanisms. For example, the consistent with the free market policies of central government the MAF reduced its involvement in quality management by transferring responsibility to monitor product quality to the sector producers and processors. Managing the risks associated with product quality became an increasing concern to the dairy companies (Fawcett, 1989).

Two research organisations were established to specifically support the work of dairy farmers, processors and marketing companies in the milk product value chain. The Dairy Research Corporation (DRC) was established in 1990 as a private company with two shareholders, the NZDB and AgResearch (a Crown Research Institute, discussed further in Section 4.0). The DRC mission is, '*to develop and promote innovation in NZ dairy farm production.*' The DRC performs farm production research using a combination of Public Good Science Funds and dairy sector investment in R&D. The Dairy Research Institute (DRI) is a wholly owned subsidiary of the NZDB and performs food technology for milk processors and marketing activities. A third organisation providing specific services to the dairy is the Livestock Improvement Corporation (LIC) which is also a wholly owned subsidiary of the NZDB. The LIC mission is to:

> *'To maintain the sustainable net income of New Zealand Dairy Farmers by enhancing New Zealand's competitive position as a low-cost efficient producer of milk.'* (Livestock Improvement Annual Review, 1995, p4.)

To perform towards this mission the LIC providing semen technology and information services, including a nation-wide network of consulting officers who facilitate dairy farm discussion groups. The LIC is responsible *for the Board's* [NZDB] *farm production activities and, in particular, dairy herd improvement and herd records.* (Livestock Improvement Dairy Statistics 1994/5, 1995, p3.)

Co-operative dairy companies perform some in-house field and food technology research for their suppliers. Universities support the sector through education and research programmes, often in collaboration with other research organisations. The CRI are contracted to perform specific technical research related to issues of production and processing. Marketing and distribution activities are performed by nine milk product holding companies located around the globe. These companies are supported by R&D performed by off-shore Regional Development Centres (RDC) for formulating strategy and developing markets.

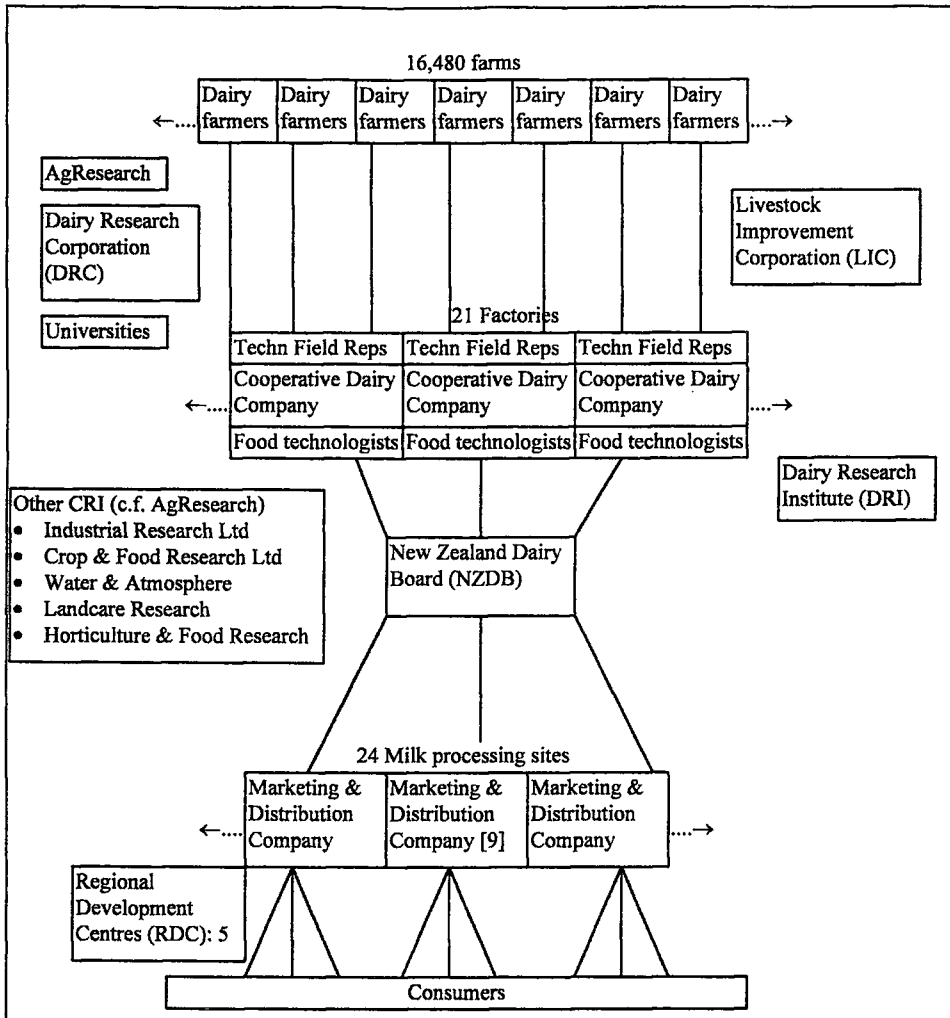


Figure 3.3 Vertical Integration in the NZ Dairy Sector
(as at 1995)

Strategic management of the sector is primarily the responsibility of the NZDB, though Co-operative Dairy Company strategies will influence sector developments and prosperity. Subsequent discussion will focus on farm level activities, before concluding with sector level issues of R&D management.

To remain competitive in world markets the NZ dairy sector has focused on one overriding goal - to lower the cost of milk production:

> *'Even more significantly, however, belief in the key importance of low-cost production has been responsible for the two concepts which govern New Zealand dairying - the concept of production per acre, rather than per cow, as the most useful overall measure of productive efficiency, and the concept of output per labour unit as the best overall index of economic efficiency.'* (McMeekan, 1966, p.5).

McMeekan's view was repeated in a paper summarising a famous NZ grazing trial, with a speculation that:

> *'The continued contribution of dairy production research to the industry requires increased emphasis on reducing the on-farm costs of production, and the application of new technologies to increasing further the output per labour unit and to developing cows that better meet the needs of the farmer and marketplace.'* (Bryant, 1990, p.55.).

Low cost production moreover drives the planning and performance assessment of sector servicing organisations like LIC (see section 3.3).

Holmes (1990) argued NZ dairy farms were internationally competitive because they produced milk at a lower cost than other producers in the developed world - claiming total farm working costs on NZ farms were equal to the feed costs alone on USA and UK farms. Holmes contended the sharemilker system of tenure was a second factor responsible for the sustained competitive performance of the sector. The vertical integration of the dairy industry was a third factor affecting sector performance by promoting a specialised pastoral system that turned grass into milk for subsequent processing into a range of products sought by consumers (see Table 3.7).

Table 3.7 Total Manufactured Dairy Products (millions)

	1991	1992	1993	1994	1995
Total Milk (*l*)	7,870	8,186	8,365	9,368	9,200
Liquid consumption (*l*)	342	340	340	340	340
Milk for processing (*l*)	7,303	7,692	7,873	8,878	8,760
Milk solids processed (*kg*)	599	637	651	735	720
• creamery butter (*kg*)	215	217	207	223	225
• cheese (*kg*)	125	137	144	192	200
• wholemilk powder (*kg*)	235	250	279	306	299
• skimmilk powder (*kg*)	147	136	126	141	156
• other (*kg*)	182	207	219	239	241

(Source: SONZA, 1995)

3.3 Farm system research and extension for dairy farming

Farm systems research and extension (FSR-E) in NZ dairying evolved based on a working interaction of farmer, extension officer and researcher.

> *'It would not be true to claim that organised scientific research has been the mechanism responsible for all the advances made. Much of the progress has been due to the farmers themselves. By trial and error, and to a large degree by using the same reasoning processes and using the same approach through observation and experiment that characterises science, they have done much of the job without organised aid. Yet it is true to say that most of the changes have been based on research.*
> *....In all this work, the contribution of the trained agricultural adviser has been of untold value. Research is useless unless applied. The extension officer in New Zealand has an enviable record of achievement in the way he has carried the results of research*

> *to the field, tested new ideas on a pilot scale, and finally guided the intermarriage of research and practice in the complex business of farming. In addition, he has brought back to the researcher, ideas and problems that have kept science on its toes.'* (McMeekan, 1966. pp2-4)

The contemporary situation, as outlined above, has the LIC providing a nation-wide network of discussion groups for dairy farmers. These discussion groups are funded by the NZDB as means of fostering innovation in the sector. An LIC liaison officer mediates a link between the work of the DRC and the consulting officers who facilitate the discussion groups.

> *'Mr Bodeker said the farm management focus within the LIC had improved in recent years with greater interest from the LIC board and the formation of a separate farm management board which includes senior staff.... Brian Wickham, manager of the LIC planning group, said dairyfarmer profit had been a focus of the farm production group for years. Research, extension and application must go together if farmers' profitability is to continue improving. The approach must be integrated, not comprised of little bits working in isolation.'* (NZDE, Aug 1993, p.55).

However farmers interact with many other professional services in a 'typical' farming year (see Box 3.4).

Box 3.4 Professional Contacts With Farmers in a 'Typical' Year

Farmers in the Waikato/Bay of Plenty region typically receive more than 25 visits a year from servicing professionals including:

Service Professional	**Visits/yr**
Vets	15
Merchants	2-3
LIC Consulting Officer	2-3
LIC semen & herd tester	2
(N.B. the AB technician makes about 40 visits in the season during insemination)	
Environment Waikato	2
Dairy Company representative	1-2
MAF Shed inspection	1+1
(1 compulsory, 1 requested)	
Fertiliser Company representative	1

(Smeaton, 1996, 26 March, per. comm.)

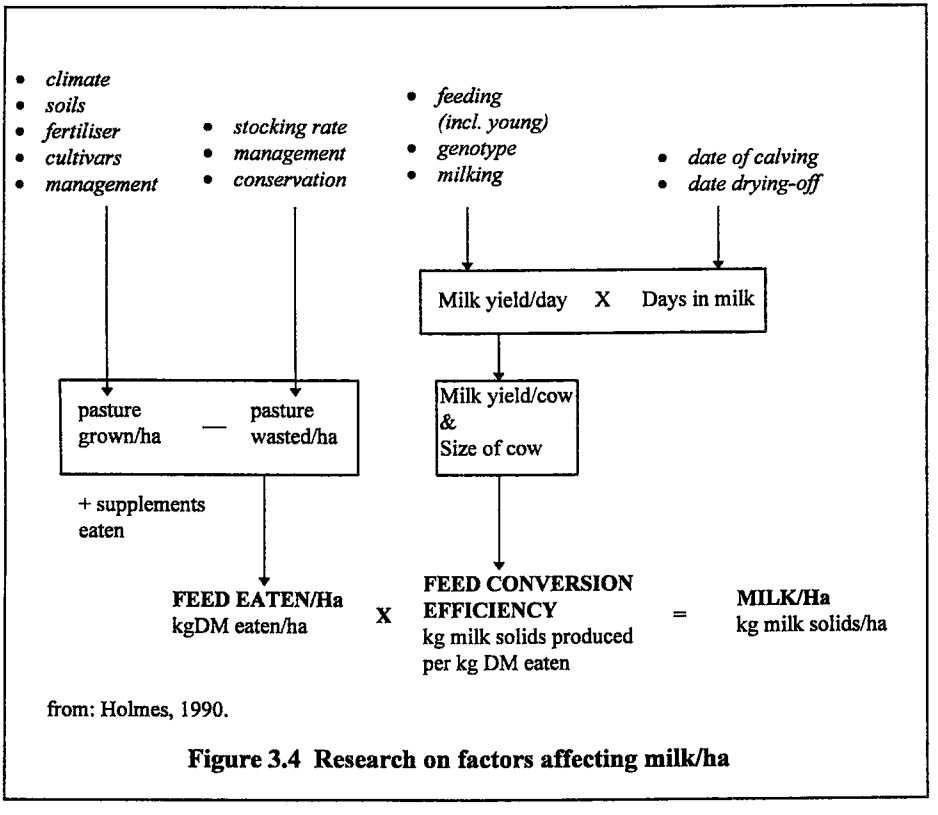
Farmers also interact with contractors who perform *one-off* services like drainage, trucking, hedge trimming, topdressing, fencing, and hay/silage making. Finally, considerable information is exchanged at informal locations where farmers routinely discuss topical issues at the pub or community hall.

Research on low cost farming systems was initiated in the 1960's by following six decision rules as established by trials on the No. 2 Dairy at the then Ruakura Agriculture Research Station, now DRC (McMeekan, 1966):

1. *grow as much grass as economically as practicable;*
2. *adjust the variable supply of fodder to the needs of the herd;*
3. *carry enough stock to use all the grass grown;*
4. *use animals that will process this grass efficiently;*
5. *harvest all the product by good milking management;*

6. minimise herd wastage by control of disease.

These decision rules have been followed by generations of New Zealand farmers and researchers because they are adaptable to technological advances, and appreciate the economic and biological constraints influencing system performance. Researchers have emphasised that the routine task for farmers is continually aligning and balancing (within and between seasons) feed supply and feed demand (see Figure 3.4). Researchers prioritise stocking rate as the dominant factor affecting milk production up to the point that grass is fully utilised (McMeekan, 1960; Bryant 1980; Holmes, 1990). When the farm system fully utilises its pasture, increased milk production will depend on improving feed supply and the conversion efficiency performance.



from: Holmes, 1990.

Figure 3.4 Research on factors affecting milk/ha

By *fine tuning* the pastoral system, following the basic rules, first described at Ruakura No.2 Dairy, farms have tended to improve per hectare production from 310 (1981/82) to 405 (1995/96) kilograms milkfat while increasing farm and herd sizes (Livestock Improvement, 1996). Researchers in DRC use a combination of laboratory techniques, farmlet trials, farm surveying and computer modelling to perform dairy systems research towards assisting farmer decision making towards improving the genetics and management of their herds.

Extension and farm management research in NZ has in the past been performed by Massey and Lincoln Universities. Periodically surveys of farmer preferences for sources of information have been commissioned by dairy sector organisations. Unfortunately these surveys can be more misleading than useful in terms of understanding farmers' preferences for information. For example, a recent survey claimed farmers preferred the use of non-interactive relative to interactive methods to access research information (see Box 3.5). Information on videos and dairying journals is amenable to storage and selective use on farm specific problems through the season. The summarised survey results in Box 3.5 suggested farmers expected research to provide factual knowledge, rather than stimulate a shared process of inquiry about farm management. Though farmers may reflect on their actions when viewing or reading an article, their reflections are bound by the scope of the hard copy information - it is essentially a one-way learning process. If farmers' only experience with scientific information is in the form of written material, then they may well rate interactive methods less significant that non-interactive communicative methods. These issues of media relate to a wider concern with linkages between science and commercial institutions which is problematized further in Section 4.0 below.

Box 3.5 Valued Sources of Information to the Dairy Farmer?

An *MRL Agriculture* multiple answer telephone survey of 991 respondents queried farmers' views on the best way to keep up to date with research relevant to their needs. Their responses were as follows:

Information Source	%Mention		% Mention
Videos: (incl: *Farming with Pictures*)	40	TV programmes	4
Dairy Exporter	32	Dairy board advisers	3
Other farm journals	22	Meetings	3
Direct mail	16	Dairy company advisors	3
Field days	12	General media	2
Discussion groups	11	Radio (include: farm session)	2
Magazines/journals	10	Dairy Board circulars	1
Consultants (incl: LIC CO's)	8	LIC advisors	1
Conferences/seminars	6	Vets	1
Dairy company circulars	6	Open days and demonstration farms	1
non-specific printed matter	5	Other	4
Newspapers	5	Don't know	2

(Source, NZDE, 1995, Sept., p9.)

In contrast to the periodic surveying of farmers, Parker *et.al.* (1994) argued for more inter-disciplinary co-operation between animal and farm management researchers[3] as part of an wider linkage with workers in the market channel (p.361):

> *'The environment for agricultural research in New Zealand in the 1990's is significantly different to that which confronted scientists in the 1960's. The new setting includes a shift in emphasis towards sustainability and more 'risk' in business. Resolving problems and opportunities in this setting will require interdisciplinary co-operation and mechanisms to be put in place (through the allocation of funds) to ensure*

[3] In NZ extension research is performed with the Farm Management Department at Massey University.

that the earlier call for interdisciplinary co-operation by Blaxter[4], Chandler[5] and others are heeded rather than simply given lip service. Farm management specialists have an important role in building linkages in the agri-food system both upstream and downstream of the farm. Animal welfare, product supply and quality, and the sustainability of production systems are emerging areas where co-operation between farm management and animal science research are essential. While recent changes in science funding in New Zealand emphasise more efficient resource use, greater accountability to science users and a higher degree of co-operation, the attainment of the national goal may be hampered by competition for limited funds and the relatively poor ability of the science output classes to handle research that spans across several output classes (i.e. systems).'

It remains to outline the future challenges for the future of dairy farming and the NZ dairy sector as whole.

3.4 Strategic issues confronting NZ dairy farming

Given the historic contribution of R&D to the dairy sector, how is science preparing to serve dairying in future? The strong vertical integration in the dairy sector enables a comparatively large ($55 million/annum) R&D investment by the sector in production, processing and marketing activities.

'An ongoing commitment to product and process innovation remains a central plank of the Board's effort to capture emerging global market opportunities in the branded consumer, ingredient and food service markets. In 1994/5, that commitment translated into total industry expenditure on research and development of $55 million, representing 1.1 percent of gross revenue, and matches the level of expenditure of major international food companies. The industry's vertically integrated structure ensures maximum return is gained from this substantial investment, with in-market companies relaying their on-the-spot assessments of market trends and customer needs to R&D providers throughout the industry .... The past year has seen progress in several areas of research relating to an environmentally sustainable industry. The NZDRI, the Board and several dairy companies have been investigating initiatives such as water recovery and reuse, CIP chemical reuse and the recovery of protein from waste streams. The industry is also formulating a strategy which takes into account the possibility that in the post-GATT era, some countries may introduce technical or environmentally-linked barriers to trade.' (NZDB Annual Report, 1995, p.19).

A recent research strategy, commissioned by the Foundation for Research, Science and Technology to inform their public good science funding (PGSF) for the dairy sector, identified nine strategic issues that collectively form a *vision* statement (FRST, 1995), viz.:

- Global opportunities are anticipated following the GATT agreement: reduced subsidisation; static world production and increasing consumption particularly near NZ

- Growth in market for core products from $24 billion to $37 billion over 5 years, NZ exports expected to almost double in this time

[4] Blaxter, K.L. 1961. Economics and animal husbandry. Journal of Agricultural Economics 14:303-313.

[5] Chandler,W.V. 1962. Production economics and problems of animal production. Proceedings of the New Zealand Society of Animal Production 22: 142-158.

- Branded, differentiated, added value consumer and industrial products pivotal to sector success
- New detection and extraction technologies will lead to new consumer products
- Farm production research to extend benefits of low production cost systems that are sustainable, including the extension dimension of farm systems research
- Systems for complying with the Resource Management Act - environmentally friendly
- Extend Quality Management Systems for product safety
- Innovative product development to customise products to cultural demands
- Greater public scrutiny, particularly environment & animal welfare issues, require appreciation of consumer values and concerns.

These strategic issues were worked into guiding principles for developing the dairy sector strategy in terms of *Dairy production systems* (low cost sustainable systems); *Animal health and welfare* (Tb and other disease control, and welfare practice); *Improve milk characteristics* (genetic and physiological basis of milk quality); *Milk products* (new processing and handling methods). Allocation of PGSF will align with these research areas (see Table 3.8). The PGSF primarily supports production system research, with sector based funds (NZDB and dairy companies) underpinning the majority of dairy research expenditure on milk processing and marketing.

> *"It is important that we argue in terms of performance and potential. The dairy industry has a strong commitment to research.... What other industry accounts for 20% of the country's exports or has such a good infrastructure in place to capture benefits from R&D?"* (NZDE, March 1992, p.26).

Table 3.8 Public Good Science Funding Trends for Dairy Research ($000's)

	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
Dairy Production Systems	3,650	3,850	4,159	4,456	4,703	5,087
Animal health (inc. TB) & welfare	1,660	1,758	1,850	1,955	2,034	2,173
Improved milk characteristics	3,210	3,326	3,671	4,020	4,449	4,692
Milk Products	3,240	3,316	3,522	3,702	3,940	4,248
Total	11,700	12,265	13,202	14,133	15,126	16,200

(Source, FRST, 1995)

Funders, providers and users in the NZ science system consider the dairy sector a good example of successful partnership and role differentiation between the public and private provision and use of science and technology. Joint ownership of the production research organisation (DRC), an exceptional track record in the transfer of

technology among farmers, and the blatant public statements about sector dependence on innovation add up to a system of research management consistent with Government policy. This study selected the dairy sector for its apparent success in linking public and private funding and use of R&D achievements. The strategic relevance of the sector to CRI, the ease of access to sector data, and the active extension service were additional reasons for selecting case studies in this sector. The dairy sector therefore provided a context for conducting research on linkages among scientific and commercial organisations with a reasonable chance of identifying situations involving interactive activities among actors. It remains to discuss the development of the NZ science system, with particular emphasis on managing technology, before submitting the problem statements.

4.0 Change in the New Zealand Science System

4.1 Research, Science and Technology

Free market government policies extended to reforms in the public sector research organisations. Restructuring the research organisations was a conceptually difficult task under the reforms because the organisations were perceived to potentially offer multiple public good outcomes. The institution of science was perceived to offer opportunities for building a technologically advanced society while contributing to the advancement of culture and education (MRST, 1995). The NZ response was to design a radical science system that accommodated instrumental and cultural goals in one organisational structure (Duncan and Bollard, 1992, p 166).

> 'A variant of the corporate structure has been used by the Government as a basis for its restructuring of public research, science and technology in 1990-92.'

Scientific knowledge was valued by policy-makers as a resource that contributed to innovation which in turn generates instrumental benefits for society. The Ministerial Science Review, charged with planning the reforms to the science system to align with free market policies, proposed the use of Crown Research Institutes (CRI) as an organisational structure that enabled the introduction free market efficiencies towards improving the generation of public good outcomes from the existing research organisations. Prior to the reforms public sector research was performed by the Department of Scientific and Industrial Research (DSIR), and by a research division in MAF. Universities were a third provider of public good research. Agricultural research was performed by these three providers, though MAF was expected to supply more 'near market' research that connected with its extension service. A National Research Advisory Committee co-ordinated research priority setting across the organisations, however periodically complaints were made by researchers and sector organisations about duplication and gaps in research programmes. Following the reforms, the DSIR and MAF were disbanded to form the CRIs. The CRIs have a corporate form and are owned by Government. The Ministers of Finance and CRIs are the two shareholders of CRIs. This ownership structure is guaranteed, CRIs will not be privatised. Ten CRIs were established in 1992 to align their delivery with the needs of NZ productive and resource sectors. Each CRI had to structure itself as a financially viable institution, paying taxes and subject to dividend payments. The

Social Research Institute was disbanded in 1994 following a series of failures to compete successfully in a contestable research market.

The principal objective driving the management of CRI is: *'..to operate in fields of strategic importance to New Zealand and undertake research and provide services to the country's benefit.'* (Ministerial Science Task Group, 1991, p21). Contestable funding of research was introduced in the new science structure by separating science policy, funding and delivery functions. Contestability enabled competition between public and private sector providers of science as a way of improving the efficiency of research resource management. These reforms of the research, science and technology system were inspired by a model of knowledge and information markets used by the Ministerial Science Task Group. This Task Group was charged with guiding the reforms (Min. Sci. Task Group, 1991, p.150-1.):

> *'Science is often depicted as a linear progression from fundamental research which is of primary interest to scientists, to applied and developmental research which is more appropriable by users... science is better depicted as a closed loop from which technology may emerge at any point. What is important is how research results are packaged in order to make them accessible to users (not necessarily end-users). [We] propose the notion of* markets *each with its own requirements for technology transfer. CRI's will need to analyse the requirements of the markets in which their technology will be placed and choose technology transfer processes which match the market requirements. For example,* extension *is a recognised process for placing technology with farmers, but is not appropriate to a market comprised of differentiated competitive manufacturers.... There is a clear expectation that CRIs will seek to extend the range of alliances with the private sector which will results in the profitable transfer of their technology. However, Government's policy makes it clear that it does not wish CRIs to engage in* ongoing *commercialisation of their technology in their own right, but proposes that CRIs seek appropriate commercial arrangements with the private sector.'*

It is left to the CRIs to determine their particular mix of technology transfer methods to *market* their technologies. Policy-makers provided little comment on the processes that would *work out* the concepts, tools and methods that would ultimately constitute a technology in demand. A potential managerial dilemma confronts CRI's who operate as commercial organisations, yet deliver long term public good research. How does an organisation, whose *raison d' être* is to deliver and promote excellence in research for New Zealand, make profits with minimal risk to shareholders? The new structure proposed to resolve this dilemma by using a Foundation to purchase research for the public, using criteria of science quality and sector relevance. The relative emphasis in the types of public good research purchased by the Foundation is indicated in Table 3.9. The purchase of agricultural research was included in the overall vote to primary production. Following the restructuring of the science system, science priorities were organised around economic, quality of life and knowledge output criteria. Though each CRI can bid for funds from any of the output classes, CRIs tend to focus their capabilities and scientific outputs within their historic competencies. The CRIs who serve the agricultural sectors bid into the primary production output classes. These classes currently receive 45% of the total vote for science, but this will reduce to 31% in the next 5 years. These CRIs therefore confront a challenging future to encourage a significant increase in sector R&D investment.

The CRIs were also encouraged to offer fee for service delivery to the productive sectors. This structure supported the growth of those CRIs that were more successful than their counterparts in satisfying quality and relevance criteria in both public and private arenas. Government expected all CRIs to survive by using the comparative advantage of their specialised capabilities to more successfully align with certain sectors than their competitors. To explain the logic underpinning this structural solution, the question of public and private sector beneficiaries will be addressed and expanded.

Table 3.9 Aggregation of Science Outputs

Broad Output Class Aggregation	PGSF 1992/93	
Economic Development	$ 165m	71.1%
Quality of life	$ 45m	19.4%
Knowledge	$ 22m	9.5%
Aggregate Class	1992/93 Funding ($ million)	1997/98 Funding ($ million)	% Change
Primary Production	108.3	93.2	-13.9
Secondary Production	49.3	63.8	+29.4
Infrastructure	7.9	9.2	+16.5
Social Science	1.6	4.4	+175.3
Environmental Protection	9.6	10.1	+5.2
Earth Exploration	47.7	42.7	-10.5
Fundamental knowledge	3.0	3.6	+20.0
Miscellaneous	4.6	4.9	+6.5

(Source: FRST, 1993)

How can public good research be equated with specialised sector capabilities? The new science system is adequate to handle resource allocations to research national concerns like the development of bioeconomically sustainable agricultural systems. A more complex situation involves issues like quality management, where publicly funded scientific knowledge potentially benefits the competitive performance of a sector. In the latter example, the principal, but by no means only, beneficiaries are sector members. A potential to expand valued export receipts may prompt public investment, even when sector investment is not forthcoming. The public may choose to take an investment that a sector deemed too risky, that if successful will primarily reward the very sector not prepared to take such a risk. In this situation, the public good takes the form of expanding sector competence to a point where it will self

perpetuate and return long term benefits to the national economy. The rationale for this action is that science facilitates a commercial world to a new level of knowledge that will open opportunities to manage biological and social resources at a profit. This profit will depend on successfully aligning strategic and applied research, and on managing the interactions between public and private sector R&D activities. The Minister for Research, Science and Technology identified the importance of managing sector interactions relating to R&D activities in 1993:

> *"Perhaps the most important outcome of the reforms in the science system will be the forming of linkages between science, users and the wider community. This is where our focus needs to be now that the structural changes have been made. In particular, the Government wants to see its own investment "leveraged" through closer, more productive relationships between the science system and the private sector."* (Upton, 1993, p11)

The development of linkage mechanisms were fostered under the reforms using the Technology for Business Growth (TBG) scheme. An annual fund of $10.6 million is available to catalyse technological innovation in industry by part financing joint projects between research institutes and firms (MRST, 1994). The selection criteria are based primarily on the prospect of commercial success ensuing from the proposed project. Rsearch companies like CRI can access TBG funds to partially resource their technology transfer activities, though these funds do not extend to resourcing the development of extension research that may be critical to improve the appreciation of farmers' preferences. Sheath and Paine (1996) recently suggested that changes in TBG policies need to consider using a more encompassing perspective of technology management - spanning design, development and marketing activities - towards improving funding allocation with respect to appropriate linkage arrangements.

Another aspect of the reforms relates to the morale of the researcher workers. How have research workers in the CRI reacted to the reforms and subsequent challenges? Berridge *et. al.* (1996) surveyed NZ scientists and concluded (p.49):

> *'The organisational changes have produced a largely negative response from the scientific workforce already traumatised by the preceding funding losses*[6]*. Restructuring, loss of about 30% of the scientific workforce, short term funding, bad management and difficulties involved with the administration of the Public Good Science Fund, including greatly increased paperwork, has prevented general acceptance of the reforms.'*

Research workers were portrayed in the paper as devoted to their science disciplines, yet with a growing sense of insecurity in employment following the reforms. A separate study investigated the innovative achievements of researchers prior to the reforms (Bray and Perry, 1994). Their review of research programmes performed by the DSIR throughout the 1980's. About a third of what DSIR reported as research achievements (innovations) were implemented, though only a small portion were reported as commercially successful. The authors concluded that market feedback was a critical factor affecting the success of programmes (p.47):

> *'Some support for scientists' criticism of local industry is perhaps indicated by the characteristics of the most commercially successful innovations identified. Those arose in cases where scientists did not need to obtain industry support at the outset of the project because the innovation was targeted to a market that the scientist was already*

[6] Public funding of research declined by 30% from 1981 to 1991.

operating in. ... Consequently, this experience is perhaps more a reflection of the way other projects have failed to secure appropriate forms of market knowledge and commercial investment, rather than suggesting there is no place for commercial partnerships.'

The CRI reforms were an attempt by government to improve the connections between public research and private sector organisations. The following section discusses the challenge the reforms have created for research organisations in the context of the dairy sector.

4.2 Market channel alignment and science system alignment

Prior to the reforms the government extension services, among others, performed a brokerage role linking scientific and commercial activities in the productive sectors. Extension, as the brokering of information to improve sector-wide farm system performance[7], altered radically in NZ following the changes outlined in Section 2.0 above. The reforms to MAF involving the privatisation of government extension services began in 1987, and concluded with the sale of the agricultural consultancy business in 1994 (Ballard,1996). During this same period MAF transferred its agricultural research activities to the CRI companies in 1992. Prior to 1987 MAF employed 5600 staff. Following the structural adjustments this number reduced to 2300, with 2050 of these employed in Quality management, destined for corporatisation by 1998/99. When the reforms are complete, MAF will employ about 250 people in core ministry areas of policy and regulation. The MAF vision is to add value to agriculture and horticulture using 4 strategies that align with its mission statement (see Box 3.6).

Box 3.6 MAF Mission and Strategy Goals Following the Reforms

Mission
To contribute to the Government's agriculture and agricultural and horticultural objectives for enterprise development, growth and profitability, sustainability, market access and agricultural security.'

MAF's Strategic Goals for the next five years are:
- Attain the best possible access to world markets for export of primary product from New Zealand.
- Reinforce national and international recognition of New Zealand's healthy and humane image.
- Develop a domestic business environment that enables New Zealand agribusiness to fully exploit market-led opportunities.
- Achieve international recognition for leadership in land-based industry practices that result in the greatest long-term economic and social benefits to New Zealand and sustainability of our resource base.

(Ballard, 1996, p.22)

[7] A now conventional definition of extension is, 'a professional communication intervention deployed by an institution to induce change in voluntary behaviours with a presumed public or collective utility.' (Röling, 1988, p.49). A vast range of '*communication interventions* ' are available to extensionists, including mass media, group and interpersonal communication methods. My emphasis is on those processes related to the development of professional working relationships that deal with farm systems.

A change in organisational culture was reported with the change in the MAF role to agricultural sectors. Ballard distinguished the changes in MAF culture in relation to the reforms (p.22):

> *'As important as the change in the numbers has been the change in the organisational culture required by the change in work environment. Prior to the reforms, this culture was characterised by service to the public, for the greater good with an emphasis on doing a good job, no matter what the cost or how long it took. This was driven by an environment of jobs for life; automatic progression on length of service; expanding staff numbers; and a liberal and expanding budget. The new environment of user-pays, competition, reducing government funding and job security based on skills and performance requires a culture characterised by service to clients, with government seen as the prime client, and an emphasis on doing a good job within tight timeframes and limited budgets.'*

Ballard contrasted '*doing a good job*' as a public servant (apparently no resource constraints) with '*doing a good job*' as a hybrid that serves the public using commercial operating procedures and values. This shift is achieved by removing '*the greater good*' and replacing it with '*government*' as a principal client. A more targeted and accountable approach to service delivery was implied in this shift to treating the government as client. A comparative assessment of the public good merits of this shift in culture would likely confront several questions, viz.:

- Who is government?
- How does this government now perform for the greater good?
- How does this performance differ from the performance of public servants who formerly served the greater good?

These questions can be answered with varying degrees of accuracy. The Minister of Agriculture represents government and operates with a comparatively reduced but focussed ministry. An accurate answer to the final and most critical question requires an appreciation of extension and other MAF services performed before and after the reforms. In particular, how did staff actually perform their work and decide what was good, and judge errors in their work relative to purpose? Comparative analyses are not possible as the nature of work has altered with the restructuring, and to date the behaviour of extensionists at work have not been analysed for this purpose. Many former extensionists (now consultants) would argue their work was highly targeted, that a client concept was not foreign to them, and that the changes in government resourcing merely denies services to a dependent group of farmers and signals to the others that information is a farm input to factor into farm production costs. Ballard only provided data on the reduction in staff numbers, many of whom were transferred to the organisations that are the prime concern of this research (the CRIs).

This need for an objective assessment of benefits from restructuring was identified as early as 1993 when the reforms were only partially implemented (Walker, 1993, p.128):

> *'No formal assessment as to how well the needs of New Zealand agriculture are being served by the current mix has been undertaken. Subjectively, however, the situation appears to be: less interaction between organisations, reduced feedback from farmers to science providers, more limited information distribution - particularly to less well-off and poorer performing farmers, and loss of extension experience in New Zealand.'*

Where previously MAF was primarily responsible for the wellbeing of New Zealand agriculture, this responsibility was divided among many organisations with specialised roles and varying accountability to government following the reforms. Further discussion will focus on the NZ dairy sector to conclude the descriptive context for organisational linkages in relation to a marketing channel.

How do these organisations interact following the reforms? While no specific study has been conducted on the NZ dairy sector, a recent workshop did compare methodologies for building working relationships among agricultural researchers and user groups, to '*stimulate the further development of this work in New Zealand* ' (Lowe, 1995). Participants attended from several CRIs, primary production sectors, and universities to share their work experience and build a diverse picture of technology development activity across the nation. Material generated by the workshop provided a recent review of technology transfer activity in New Zealand agriculture (Jiggins, Röling and McRae, 1995). That the event was funded by an independent Trust, and was attended by production sector senior executives implied some critical technology transfer issues were unresolved following the reforms. Outcomes from the workshop were framed as opportunities to:

- scale up interactive technology development using monitoring tools;
- improve farmer to farmer diffusion of innovations using study groups;
- use more social science in programmes;
- and improve the development of professional staff involved in technology development programmes.

Realising these opportunities will depend in part on the emergence of working relations among the organisations in the sectors which develop and use new technology.

5.0 Problem Statement

Dairy farming in NZ has emerged from a mix of changing cultural, economic and technological forces operating on the land and its people. Under the current science system reforms the CRIs will require significant increases in agricultural R&D investment from the pastoral sectors to remain in their current form. The aim of this study is not to question the appropriateness of the above mentioned reforms, rather to identify opportunities to improve the performance of organisations in the science system by enhancing interactions between researchers and the agricultural sectors. Research organisations are developing and using a variety of mechanisms to better link their work with productive sector activities. The way organisations approach this linkage is influenced in part by the prevailing theoretical perspectives that underpin their actions. Science policy in NZ has been guided by market theory. Knowledge is depicted as a tradeable commodity in a society where the market confers IP rights and uses contractual instruments to reward the company that provides knowledge. Power in knowledge markets is achieved by regulating the ownership of knowledge. The law of contract provides the principal instruments for exchange in knowledge markets (Noorderhaven, 1990). A more complex dimension to R&D partnerships, as working relationships in a market based science system, involves the social responsibilities of the organisations that make up the science system. Solomon (1992) believes the

notion of *social responsibility* is often wrongly applied in commerce due to an emphasis on organisations as individual entities. He argues organisations cannot effectively analyse their social responsibilities when they separate themselves from their constituent society.

> *The first principle of business ethics is that the corporation is itself a citizen, a member of the larger community, and inconceivable without it. This is the idea that has been argued over the past few decades as the principle of "social responsibility," but the often attenuated and distorted arguments surrounding that concept have been more than enough to convince me that the same idea needed a different foundation. The notion of "responsibility" (a version of which will, nevertheless, be central to my argument here too) is very much a part of the atomistic individualism that I am attacking as inadequate, and the classic arguments for "the social responsibilities of business" all too readily fall into the trap of beginning with the assumption of the corporation as an autonomous, independent entity, which then needs to consider its obligations to the surrounding community. But corporations, like individuals, are part and parcel of the communities that created them, and the responsibilities that they bear are not the products of argument or implicit contracts but intrinsic to their very existence as social entities. There are important and sometimes delicate questions about what the social responsibilities of business or a particular corporation might be, but the question whether they have such responsibilities is a non-starter, a bit of covert nonsense. Friedman's now-infamous idea that "the social responsibility of business is to increase its profits" betrays a wilful misunderstanding of the very nature of both social responsibility and business."* (Solomon, 1992, p148-9)

Solomon views social responsibility as inseparable from an organisation's purpose. In the context of the NZ dairy sector, issues of organisational purpose are particularly relevant to the recently formed CRIs that provide technologies to members of the market channel. In this context, the purpose of the research company, and other organisations who manage information towards improving the international competitiveness of the sector, is directly related to performance in theatres of innovation. Hence Solomon's argument that the purpose of, for example CRI's, is inseparable from ***the performance of the theatre of innovation.***

Problem Statements

1. How do organisations and actors link their activities to evolve technology for use in the NZ dairy sector?
2. How can an understanding of these linkage activities inform technology managers in the dairy theatre of innovation?

Three case studies, reported in the following chapters, investigate: the development of a component technology; the implementation of a quality management scheme; and the use of study groups for sustainable farming, to observe the evolution of linkages in diverse dairy sector R&D programmes to determine how insights from these programmes can contribution to improve understanding of the above problem statements.

Chapter Four

An Emerging Technology: a case study of synchronising dairy cow reproduction using the CIDR

> *The dilemma for agricultural research is getting all parties to understand all the linkages and not let one particular aspect dominate to the detriment of others.* (Wilson, 1996)[1]

1.0 Introduction

This case study will investigate the interplays performed in the development and commercialisation of the Controlled Intravaginal Drug Release (CIDR) device. The CDIR is a silicone device impregnated with progesterone to regulate the cycling of breeding livestock, particularly dairy cows. A socio-technical outline of the development history of CIDR is represented in four stages spanning the initial activities of the actors who designed the device through to the use of CIDR in contemporary farming. These stages coincide with chronological milestones in the development and use of CIDR. The activities of actors, who performed different practices required in the development and use of CIDR, are investigated to improve understanding about the way actors coordinated their work around an emerging technology. Significant events in the working lives of actors are explored over several development stages of the CIDR history. From these events critical issues for management of the technology are identified and later discussed in terms of the learning that emerges out of these events and issues.

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[1] Wilson, K. 1996, The dilemma of agricultural research, NZ Rural Business, No1. Summer 1995/96, p.3.

2.0 A Farm System Context

Pasture based dairy farming in NZ provides a narrow window of time to get cows pregnant. Chapter 3 established that total yield was a function of yield/day x days in milk, the latter determined by farmers decisions when to calve and when to dry off. The domesticated dairy cow has a 280 day pregnancy. Cows on high performing seasonal supply dairy farms in NZ require at least 40 days to recover from calving before mating for following season production and calving. Bovines cycle every 21 days, leaving the NZ farmer with 2 natural cycles to maintain an annual balance between feed management and milk yields.

Adverse weather can constrain pasture feed supply and undermine herd reproductive performance if farmers do not use countermeasures like the feeding of comparatively expensive supplements. Costs from not getting cows in calf every 365 days include later calving (i.e. the system is out of balance with the annual cycle) and more *empties* (cows without calves and therefore non-yielding[2]). Farmers can return an out of balance system to a 365 day cycle by opting for fewer cow days in milk, higher culling or more inductions. The latter is a drug treatment forcing the premature birth of the calf - a loathsome option to many farmers and presumably consumers. Development of the CIDR provided farmers with another alternative that worked on the opposite end of the reproductive cycle to inductions. By controlling the release of progesterone prior to mating, farmers could synchronise the cycling of their herds, control the timing of artificial inseminations and ultimately maintain a compressed pattern of calving. Furthermore, the CIDR has been acknowledged as assisting farmers to counter what may be a decline in fertility - a type of feedback effect in the biological system resulting from increasing selection pressure for production traits:

> *'Has increased genetic merit for milk production caused a decrease in fertility, and by how much? Where would we be without techniques including CIDR and inductions? .... Calving dates would be slightly later each year in the absence of interventions including CIDR and inductions ... work by Jock MacMillan and others has resulted in compact calving patterns.'* (Holmes, NZDE, 1995)

The questions posed in this case study are what were the critical activities involved in the development of CIDR, who performed them, why did these actors actively contribute to the technology development task, and how did they go about the job of working together?

3.0 The Origins of CIDR

3.1 Significant Events

This section opens with a discussion of the development of CIDR hardware. Discussion of the development of the hardware device provides a point of entry into the other aspects of practice performance, viz.: the social world of the actors, and the

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[2] *'An empty is NZ jargon for a cow which is found to be not pregnant at any time after the 12 to 14 week breeding programme. It has lost its ability to contribute to the following seasons production. This 'indiscretion' is regarded as the cow's fault, it is culled!'* (MacMillan, per. com.)

development of their concepts relating to the technology. The components of the CIDR device originated from two theatres of innovation developed during World War Two. The development of polymer engineering during the war was prompted by a need for rapid lightweight repair materials for aircraft and shipping. Silicone products were among a suite of polymers that emerged as a response to the needs of the war effort. Organic chemistry was the second source of innovations linked with the CIDR. Agrochemical products were developed to remove much of the drudgery in post-war farming. Agricultural chemists developed products that were intended to offer farmers more control of their farm systems and thereby improve their yields and profits. The acme of the agricultural organic chemist was in the 1950's, giving way to physiologists and hormone research in the 1960's. By the 1970's exploding pest populations and environmental degradation warned of potential backlashes from the indiscriminate use of agrochemicals. Some technologists responded to this feedback by pursuing the development of controlled release substances. A controlled release society was formed in the USA which published a journal and possessed a diverse membership of medical, industrial and agricultural researchers.

During the 1970's several hormone release devices had been developed in Europe and released internationally for the intravaginal administration of hormones to farm animals. Different substrates were used to deliver the hormones to animals. One device used a sponge arrangement that was soaked in hormone and then inserted into the animal for several days. Another device was fabricated as a plastic spiral that was similarly inserted intravaginally to administer the hormone. New Zealand was among a number of countries evaluating the performance of these devices under local conditions. A Dr W---, a reproductive physiologist employed by a government research organisation, was working on the evaluation of these recently released devices. He was dissatisfied with a number of attributes of these devices, particularly their use of synthetic hormones, the trauma they caused to the animals, and the difficulties encountered in administering them. Dr W--- set about the task of formulating an alternative device that used naturally occurring hormones while minimising animal trauma. His development interests were tolerated, rather than supported by his senior management. Dr. W---'s evaluation work had alerted him to the use of plastic in the manufacture of devices. He contacted a local plastics manufacturing company and was directed to Mr M--, then recognised as a leading plastics fabricator in NZ. Dr. W--- demonstrated the available devices to Mr M-- and discussed his intention to develop an alternative device. The problem intrigued Mr M---, particularly the need for controlling the release of hormone from a polymer based device. As they discussed issues surrounding development of the device they identified the dominant design problems to be the shaping of a device that was capable of yielding appropriate hormone release properties when manufactured at a rate and scale of production to be commercially viable. If the naturally occurring hormone progesterone could be impregnated into a polymer device, remain stable, and diffuse from the device into the animal at the correct rate of release, while the animal retained the device they would be able to achieve their design objectives. The two workers decided that the design problems were not insurmountable and established a work programme to trial the shapes of prototype devices and determine hormone release profiles. Work on the trials determined that the critical challenge to achieving a commercially viable device was to identify a polymer substrate that could be

fabricated at a temperature that would not denature the progesterone impregnated in the polymer.

The cost and scale of polymer research plants was beyond the resources of New Zealand. However Dr W---'s membership of the Controlled Release Society provided contact with a number of international researchers, one of whom had worked with polymers in the field of medicine. The medical researcher directed Dr W--- to a polymer engineer in a multinational engineering organisation that had developed a prototype silicone substrate that appeared to possess the attributes sought by Dr W--- and Mr M---. The engineer sent a sample to the plastics manufacturer for evaluation. Subsequent trials determined that the silicone substrate provided the physical attributes required, enabling Dr W--- and Mr M--- to concentrate on refining the shape of the device. The problem of shaping the device required access to animals for trialing the retention characteristics of different shapes. Systems researchers provided donor sheep and goats for the initial work and performed an interested observer role in the development process.

The supply of resources for the product development of CIDR benefited from a problem in another part of the plastics factory. A high-technology milk harvesting machine was suffering from a natural rubber diaphragm malfunction. An urgent solution was required as product failures were occurring in the market. A silicone based diaphragm was used to replace the rubber component as the silicone did not alter shape over a wide temperature spectrum. The CIDR accessed silicone trialing resources that would not have been available under routine factory manufacturing conditions. In particular, the factory crisis with the diaphragms enabled the CIDR work programme to offset many of the expenses that would have otherwise been involved in testing different dye casts.

3.2 Critical Issues

In the early development of the CIDR the required development activities often connected actors in unpredictable ways. A researcher made connections with other domains of work to construct a device. These connections were motivated by the problem of hormone release. To resolve the problem of release required incremental trialing of progesterone concentrations, combined with a search for a suitable substrate product. This search process introduced aspects of polymer engineering and dye casting into the development work programme. However access to these skills was dependent on access to networks of other practices. The researcher made use of his membership in a wider community or 'club' of researchers. These research clubs were practice interfaces, referred to by several researchers who developed or used the CIDR in their work.

> *'We have a little group called the conception club - we haven't met for a while - where we just get together and kick around ideas about pregnancy.'* (Scientist)

Whereas clubs perform a useful connective mechanisms among actors, formal organisational guidance or support was not critical in the early stages of development. On the contrary, the commitment of the researcher and plastics fabricator to the CIDR was not aligned with the dominant work programmes operating in their respective

organisations. However performance failures in dominant programmes, as occurred in the incident with the milk harvesting programme, provided the CIDR development effort with opportunities to access resources.

The emergence of the device was an incremental process of change flowing from a dissatisfaction with existing devices. Trial and error of prototypes stimulated the redesigning and further trialing in a stimulating problem-solving cycle. The excitement of working on problems attracted contributions from other actors towards the shaping of the device and improvement of its hormone release properties (see Figure 4.1.).

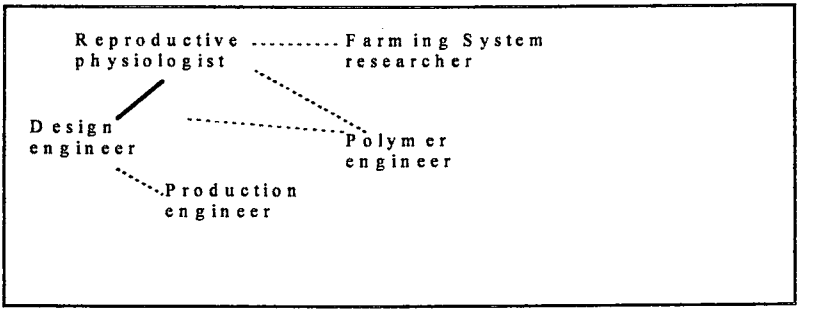

Figure 4.1 Significant actors in the early development stage of CIDR

Finally, the problem of resourcing the development effort was resolved by being alert for opportunities to access materials, funds and manpower from the dominant programmes operating in the organisations. Awareness of problems in the milk harvesting programme yielded opportunities to borrow resources for the CIDR development. Furthermore, the researcher and manufacturing designer attracted expertise by stimulating inquiry among actors interested in the challenge to solve polymer engineering or progesterone release problems.

3.3 Emergent Learning

What emerges as lessons for effectively performing joint development tasks? It appears that interplay, as the performance of often unpredictable work activities in development programmes, requires some alignment among actors. These actors align in terms of their shared interest in the problem or substantive concern, recognition of their task domains, and the inter-dependence of tasks in the overall programme. No individual actor could foresee the development tasks required of the CIDR, rather development was characterised as a *muddling through*[3] from one activity to another. The interdependence of actors in task performance was not so much a planned

[3] The term muddling through is used here to refer to an active process of emergence in practice - it implies a trial and error negotiating by the actors performing a practice

outcome as a iterative emergence of co-ordinated action. Organisations may not be capable of anticipating the direction that interplays and networking will take in development programmes, but they can be vigilant in their apprehension and support of opportunities for innovation.

A second lesson pertains to the scale of work teams and positioning of actors in the performance of development tasks. A small group of actors was positioned both geographically and within practices to access critical resources and thereby continue the development programme. Strategies emerged to access resources such as *piggy backing* which was a term the actors used to refer to the link between the CIDR and milk harvester programmes.

Networks were used extensively by actors to cross organisational boundaries in the early development of CIDR. No formal structure was required, indeed using a formal organisational structure may have stifled innovation and the freedom for actors to share their work with each other in loosely organised networking arrangements.

4.0 Device Developments for Use in Farming Systems

4.1 Significant Events

By the mid 1980's (10 years after Dr.W---'s initial idea) a number of events altered the emphasis in the programme. These events applied at the level of individual actors through to changes in national policy. Dr. W--- left the programme to take a position in Palmerston North and Mr M---'s input ended with a terminal illness. The manufacturing company was acquired by a larger New Zealand company that then restructured its operation to form a separate Plastic Products Division. The name Plastic Products Division hinted at problems that later faced the company in manufacturing pharmaceutical products. Its core business did not equip the company to deal with drug registration procedures, or the laboratory techniques necessary to develop and test products. Collaboration with the research organisation was adequate for the development effort required by the NZ Animal Remedies Board, but entering the international arena was a greater challenge. Drug registration in large markets, like the USA, required vast technical and financial resources. Entry to these markets was typically achieved by joining forces with the few large multinational pharmaceutical companies. Negotiations with a German company failed to secure a working relationship, following a visit by their R&D management team to the New Zealand factory. This team did not gain confidence in the capabilities of the New Zealand operation to perform according to international conventions for the manufacture of pharmaceutical products. They considered some of the technical procedures infeasible, and judged that it was inappropriate to handle pharmaceutical products like progesterone in a plastics factory. Changes also occurred in resource allocation guidelines for operating in the science system, following the election of the 1984 Labour Government. Consistent with the Labour Government's then free market policy, research organisations were encouraged to place more emphasis on commercial criteria in their R&D programme planning.

Work by Dr W---, Mr M--- and others resulted in the development of CIDR devices that reliably synchronised oestrus cycling in sheep and goats. These devices were developed with minimal farm system research input. Some prototype devices were also tested for heifers, but were prone to regular failures due to poor retention by the animals and failure to achieve the hormone release characteristics required by bovines. In 1986 a commercial device was released for use in sheep and goat farming operations. At that time goats were attracting high returns and CIDR sales benefited by the use of the device in embryo transfer work. The cost of CIDR devices limited their use in sheep farming to artificial insemination applications on stud farms. Returns from CIDR sales to sheep and goat enterprises were ploughed backed into development efforts on heifers. Success in sheep and goat farm enterprises, enabled developers to concentrate on systems development work for bovines. During the 1980's the scale of the programme had grown with a corresponding increase in the consumption of resources. This rise in the scale of the programme required more formal negotiation and commitment from organisations and workers. These negotiations were a regular aspect of the early 1980's, and culminated in a critical meeting in 1985. This meeting was precipitated by trials in Ireland that were using a modified goat device on heifers. Results from the trial were disastrous - so much so that the CIDR still retains a lingering legacy as an unreliable synchronising technology in that country. The manufacturing company had employed a new manager (Mr D---) who possessed a long history of agricultural technology development and marketing. Mr D--- wanted to abandon further investment in the development work, but the workers in the programme, particularly the systems developer and design engineer, argued repeatedly for a further season of field trials using a new design. Mr D--- agreed with the argument that a device was required for dairy cattle if the CIDR was to have any hope of attracting the returns expected by his senior management. The company required a technology capable of delivering reliable synchrony in an international farming system context. Agreement was reached that the nation's leading dairy reproduction researcher (Dr M---) be assigned to the CIDR programme and a further year of development funding be provided by the manufacturing company, the research organisation and the national genetic improvement and extension organisation (LIC). Development criteria shared by the actors were to produce a simple, safe, low cost synchronising technology that used naturally occurring animal hormones.

Trials with the new design were a success. Mr D---s' commitment and commercial expectations combined with Dr. M---s' sector network and scientific pragmatism were a formidable combination. Within 6 months the pair had joined forces with Mr H--- in LIC and commercialised a technology for cow synchronisation.

> *'The concept of using progesterone is not a NZ idea. The only 2 things that are patented are the shape and the moulding procedure. It's got nothing to do with progesterone. B-- W--- who was working on it originally, but I guess luck wasn't on his side in terms of getting the right shape and the right silicone and so on, and we had a meeting in 1985 to abandon the whole project, and decided at the meeting to have 1 more try. And serendipity arrived'.* (Systems scientist)

The connection with Mr H--- was critical for positioning the technology in the dairy farming system operating in New Zealand. Agreement was reached whereby the manufacturer held the patent rights on the shape of the device, royalties were paid to

the research organisation acknowledging their R&D contribution, and LIC held the sole distribution rights to veterinarians who administer the device to New Zealand animals. While early relations among researcher, manufacturer and distributor were akin to that of a friendly club, veterinarians were relative late comers in the development process. Contracts were used within the 'club' of developers as a form of insurance, something to refer to in times of a negotiation crisis.

> *...a family type of approach, even though we are quite different sorts of organisations, unless there had been that family understanding ... and the same thing exists with D—. G— has a good relationship with K—, then it comes down to J— and myself. Then you get down to other people lower down, and there are different understandings. And that trust is built up over the years.* (Distributor)

The veterinarians were not an integral part of the system development effort that preceded registration of a CIDR device for use on heifers. One explanation given for not initially including veterinarians in development work was the difference in professional training between agricultural science and veterinary science that led to a difference in orientation to technology development.

> *'Traditionally Livestock Improvement and veterinarians seem to have been at loggerheads a little bit, in that within Livestock Improvement there were Ag Science graduates, and within the veterinary profession you have the veterinary science, and historically they always seem to have had a little bit of jealousy between them, and I found it a real challenge to try and bridge and narrow that gap between the organisations, but historically or even in the way we are structured as an organisation, we are trying to as a farmers co-operative provide products and services and advice which minimise costs on farms.'* (Distributor)

However, veterinarians became involved in distribution activities because the Animal Remedies Board, the registration agency with the power to determine the fate of products and dominantly represented by veterinarians, judged that the CIDR was an animal remedy. This judgement resulted in the CIDR being made available only to veterinarians, being the only profession with a legal right to administer the device to animals.

4.2 Critical Issues

Experiences during the systems development stage of the CIDR indicated that, though the involvement of actors in the programme may change, the emergence of the technology towards a synchronising system continued. Development work, using farmlet trials and system research methods, became increasingly important as problems with device retention and hormone release rates for bovines remained intractable. This shift in development activities emphasised methodological aspects of practice, from laboratory and engineering workbench techniques to farm systems trials, necessitating a change in the relative participation of different actors in the programme. This raised the issue of managing the transition among actors. The programme as a whole needed to manage the transition of actors, as programme leaders may change their involvement along with others. In CIDR many aspects of transition management related to issues of timing. In particular, when to introduce new capabilities to the programme, when to place more emphasis on results and programme outcomes, and when, as an actor in the programme, to relinquish ownership.

The emergence of the technology was also influenced by a number of factors beyond the control of the programme leaders. Organisational boundaries were changing around the actors as they performed their work, which in turn provided new opportunities for actors to work together. As the scale of the programme increased, decision-making became more demanding to cope with problems of risk management and the introduction of new, and sometimes more complex goals. For example, the commercial expectations of managers (e.g. Mr D--) were playing an increasingly important role in resource allocation decisions for herd trials. Experiences from the attempted collaboration with the pharmaceutical company also suggested that there were limits to the use of informal networking during the development of the technology. The actors from one profession (pharmaceutical) judged the proposals of others (reproductive physiology and polymer engineering) as incompetent in relation to a shared domain of work. This judgement was based on well founded criteria used in pharmaceutical production, but overlooked the innovative opportunities offered by those outside the domain of pharmaceuticals. Those actors involved in the negotiations considered the failure to align was exacerbated by the limited commercial experience of the research company that was encouraged under Government policy to acquire more competence in marketing and commercial management.

Development failures prompted the trialing of new methods and shapes. As costs accrued actors expressed different levels of commitment to the programme. The challenge confronting the programme was to balance the encouragement of trial work, using an international network of developers, while downplaying expectations that were mounting among those parties who sought instrumental benefits from the development programme. The meeting in 1985 achieved a joint commitment among the actors, even though all actors were distressed by a history of repetitive product failures. Actors worked to further clarify the purpose of the programme and introduced the use of criteria to assist with the management of risks. These risks were encountered when, with limited development foresight, investment in the programme was accumulating yet product reliability remained elusive. Eventual success may indeed appear more a serendipitous outcome, rather than a consequence of formal planning.

The problem of developing a reliable technology for the synchronisation of bovines was not so much a prompting to search for new partners in the development, as a displacing and replacing of working clubs (see Figure 4.2). The actors within each club operated interdependently with others in the club. For example, the members of the 'device development club' were displaced by a 'farming systems research' club that focused on trialing device prototypes in farming contexts to improve the reliability of the technology. This farming systems context required a form of reliable technology that satisfied commercial development criteria, which in turn fostered networking activities to access capabilities, new to the club, from the dairy sector.

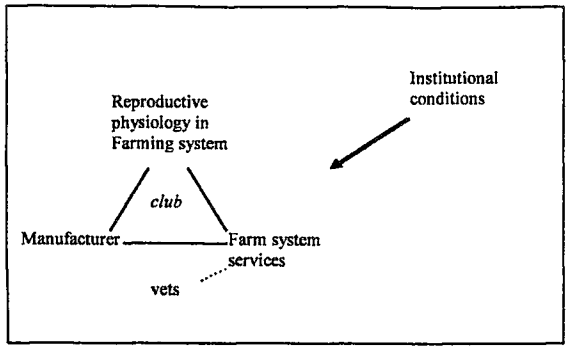

Figure 4.2 Significant actors in the development of CIDR for use in farming systems

Connections within the club were underpinned by trust and reinforced by contract, using legal instruments like patents, royalties and memorandums as safety nets to the continuity of working relationships. However, the existence of the club accentuated the boundaries between an 'in-group' of developers and an 'out-group' of veterinarians. The delayed involvement of veterinarians raised questions about whose domain of practice the CIDR technology operated within. This issue was even more evident during the stage of early commercialisation (see below).

4.3 Emergent Learning

Experiences with the CIDR suggest the technology emerged through transitions in the type of work performed in response to intractable problems. New methods of work were required to address these problems. These transitions in work methods involved an alignment among the actors in the knowledge system, which in turn required that the rules for each practice be translated into a common pool of competence to perform to the development challenge. Development work around the construction of a device therefore involved a simultaneous change in the material status of the device, the work methods employed by the actors, and the alignment of concepts constructed by the actors to cope with development problems. By changing one aspect of the technology, like the shaping of the device (material), the developers were influencing counterpart aspects of methods and actor alignment, themselves included!

The translation of rules of practice benefited from the exercise of frank inquiry, but was inhibited by professional arrogance and *patch protection*, whereby actors attempted to secure their work domain by excluding other parties. The formation of clubs of developers can encourage interdisciplinary work within the club, but exclude opportunities for new entrants, or delay and restrict the involvement of a critical practice that may result in increased development costs in the longer term. Alignment among the actors in the theatre of innovation was therefore interwoven with an interplay of practices.

5.0 Commercialisation

5.1 Significant Events

The CIDR device was registered for commercial use on dairy heifers in 1987. This registration initiated a series of development and alignment activities among the actors involved in the CIDR programme. Before investigating these activities, it is necessary to again describe those events at the macro-level that influenced work within the development programme.

Between 1987 and 1995 significant organisational changes occurred in the research and manufacturing domains. Government research organisations were restructured. As part of the restructuring process, a joint venture between the Government and the New Zealand Dairy Board (NZDB) saw the emergence of the Dairy Research Corporation (DRC) responsible for dairy production research. The DRC retained the rights to royalties on the research investment in CIDR. In 1992 the manufacturing organisation was restructured into a wholly owned subsidiary of the parent company. Actors involved in CIDR developments remained in their same premises, with access to the same facilities, while organisational boundaries altered around them. With the formation of DRC the NZDB took a more active interest in the coordination of dairy production information, including the protection of intellectual property rights (IPR) to maintain an internationally competitive position in the market (NZDE, 1992, p24-26). The management of IPR was particularly relevant to the research organisation and will therefore be investigated further in subsequent discussion of alignment in the theatre of innovation. Some actors became vocal about the impact of government policy on the theatre of innovation. For example, veterinarians were critical of reduced government funding for animal health research, implying NZ was being reduced to the status of a developing country in its service to farmers:

> *'...but with government policy supporting what appears to be hopelessly inadequate levels of research in NZ, we are unlikely to get many questions answered here. No doubt Ruakura veterinarians will closely monitor overseas literature on this subject and will inform farm vets of any developments, so that we can in turn advise you.'* (NZDE, 1990, Sept. p.88)

Marketing efforts promoting the use of CIDR by veterinarians coincided with a disastrous spring for dairy farmers in 1987. Farmers were receiving relatively low payouts for their raw milk and many experienced major herd fertility problems following the poor spring (NZDE, Feb 1987, p.41). The research perspective on the use of technology under these conditions was as follows: *'Some forms of new technology will not be adopted during periods of reduced income. But techniques which "streamline" management can be even more important in such times, because attempts are made to increase cows per labour unit.'* (NZDE, June 1986, p.55). This focus on technologies that improved labour use on farms was linked with a belief in the continuity of the family farming unit in NZ dairying.

> *'Any technology in NZ that saves time and allows the same family labour unit to milk more cows has been rapidly adopted, even if it's been the tanker, or the herring bone, and even though people have said the rotary wouldn't be economic, they've still gone in. Tail painting saves a hell of a lot of hassling and time. It may only be 90 or 95% as efficient as checking the cows 4-5 time/day, but you only have to check them once/day.'* (Scientist).

The labour consideration meant farmers evaluated (perhaps implicitly) the use of CIDR over a range of task dimensions. The intensity of tasks increased as a consequence of compressed calving patterns, *'At the peak we had a calf hitting the ground every six minutes.'* (NZDE, Oct 1992, P.13). Often more complex tasks like feed budgeting paid dividends as synchronising programmes had less margin for feeding errors and subsequent poor cow condition. Interdependence between professional services increased with veterinarians following synchronisation protocols that aligned with technicians performing artificial inseminations. Farmers gained some flexibility with their reproductive programmes as compressed calving patterns gave an additional artificial breeding round. Monitoring and quantifying components of the farm system like feed, cow condition and heats assumed higher priorities.[4] While farmers upgraded the monitoring of their farming systems to improve task performance, the resulting information from these monitoring efforts enabled researchers, veterinarians and farmers to pool their knowledge and management of reproduction (NZDE, Oct 1992, p.11).

Alignment of actors in the theatre of innovation became a development issue in its own right. At the time of registration, a market channel was organised to extend from the manufacturer through a national distributor to veterinarian practices and out to farmers. Differential power among actors in the channel meant negotiation was a critical development task. Veterinarians had sole charge to administer CIDR on farms in NZ because the technology was a registered animal remedy. When the distribution organisation detected large variations in price margins between veterinarians it informed farmers, in an effort to foster competitive efficiency in the sector. Tensions between the veterinarians and the distributor mounted until a meeting in August 1987 resolved to involve veterinarians in the development of CIDR guidelines (NZDE, Aug 1987, p.22).

> *'The product soon became registered for use in dairy cows, and I thought it would be good to sell the thing directly to farmers if we could because we would then have a selling force that would actually sign up a farmer for the use of the product, and we would then negotiate with his veterinarian to do part of the service. Now we ran foul of veterinarians with that approach, but I think that in hindsight it was actually good that that happened because it got us closer to the veterinary profession and meant that we have operated as a team since that time with them.'* (Distributor)

Veterinarians had a long standing reputation as professional practitioners in the dairy sector. A combination of client expectation and professional reputation established the veterinarian as an archetypal professional. Criticisms of expensive service were countered by a farmer (client) belief in the significance of the veterinary professional in the theatre of innovation. The professional status of veterinary practice was also appreciated by other actors in the theatre of innovation.

> *'But farmers do rate the advice that they get from vets very highly. They're seen in a lot of cases as an expensive professional. I've been to vet conferences where they have revealed their marketing surveys and farmers think vets charge too much generally. But farmers do respect their advice generally, so it would be hopeless for us to actually try and short-circuit them with that sort of mana that they have.'* (Distributor)

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[4] For example, consultants referred to target cow condition scores of 5 going into mating, with maintenance feed of 8kg dry matter per day, and 35 kg dry matter required to increase one condition score (NZDE, May 1995).

When interviewed about their use of CIDR, the farmers also expressed a belief in the commitment of the veterinarian improving animal health:

> *'To tell you the truth the vet that we've got, he likes nothing more than to come out and see a healthy herd producing well and everything going well for you. He doesn't like coming out and seeing non-cycling cows and cows under-condition and not thriving.'* (Farmer)

The initial development work achieved a reliable treatment for heifers. The developers never planned for CIDR sales to depend on the treatment of anoestrus cows. The inclusion of veterinarians assisted the development programme to offer a reliable anoestrus treatment by 1992. Veterinarians used CIDR as part of an holistic programme to treat anoestrus. Often the competence to implement an holistic programme was affected by a decline in sector prosperity and difficulties retaining experienced staff.

> *'A plea to ensure that all staff know what a cycling cow looks like ... This may sound "dumb", but since the rural downturn experienced staff have been hard to find. Many staff have to learn farming from scratch. Missing a heat even at 0.8kg per cow costs 16kg per cycle next season, which at $4/kg translates to $64.'* (NZDE, 1990, Sept, p.89)

Veterinarians secured returns on their contributions towards the development of synchronising technology by charging for professional service to the farmer. A responsibility to carry the risk of errors in practice accompanied this opportunity to charge for synchronising services.

> *'Now we won't take him in if you've got any hesitation because you are in charge as a veterinarian, and you are in charge of the synchronising service. So if it doesn't work, that part of it, then you'll be held responsible, so the vet basically has to approve the application before we then formally approve it.'* (Distributor)

These synchronising services were developed by veterinarians, employed by the distributor to offer a standardised service known as Genermate. The veterinarians worked with researchers, farmers and consultants to develop protocols that coordinated tailpainting, CIDR, Cidirol and prostaglandin treatments in a suite of management packages to service a range of stock classes and farm management situations. Synchronising technology became a complex array of devices, treatment protocols and monitoring techniques that veterinarians coordinated for their farmer clients.

The provision of support to veterinarians by other actors in the theatre of innovation did not extend to risk or profit sharing. The synchrony aspect of veterinarian practice became increasingly transparent to some of the other actors in the theatre of innovation. Some began to question which actors were performing what roles in the on-farm use of synchrony technology.

> *'I went to another seminar that Livestock Improvement had on CIDR's and they said the ultimate responsibility of deciding whether a heifer made it or not should be size. The vet should decide whether they're the right size. So I said how many vets have said that the heifers are too small, there has been none. ... Ultimately its often the farmer that will pull out of Genermate. I know of one farmer already that's cancelled Genermate because their heifers are too small.'* (Consultant)

Other actors operating in the theatre of innovation were also required to perform responsibly. Often these actors viewed science as having a privileged status that was strategically beneficial to the overall management of the technology. It was a matter of playing the technology management game according to the legal rules.

> *'The other area is that researchers can go out and talk about all sorts of applications of products, whereas as manufacturers, for us to talk about it we have to be licensed. You get differences between what we say and what DRC says based on regulatory requirements.'* (Manufacturer)

Strategies were formulated within the club that made use of networks to market the CIDR internationally. Although entry to the USA market was stalled because of earlier failure to secure a joint venture with a large pharmaceutical company, a number of smaller international markets were developed using a research network in combination with conventional commercial development activities. The working relationship generated a rich array of strategic actions.

> *I advised G--- D--- [*manager of manufacturing*] early on that one of the smartest things he could do was to make them freely available to researchers throughout the world, and the only price for that free availability was not to fund the research, but to provide the devices free of charge and to have access to the results. And if they sent the results back and they had been given a hundred CIDR, you would send them off another 100. And this took off because we were using the natural product, and that made it easier registration wise and perception wise and so on. So what's happened now is the CIDR has just gone onto the UK market in competition with the Prid, and it's already virtually knocked the Prid out of Switzerland. But the leading researchers in Britain have all used CIDR.. So although they are not necessarily marketeers, they are writing in the equivalent of the exporter [*sector farming *journals] and so on. In the US the Prid is not available commercially, it is available for research, but all the different land grant colleges have used CIDR so they know what they are. And you can go to an American animal science meeting, and you will find 6-12 papers on CIDR.. And with their extension links there is an awareness there.* (Scientist)

Dr M--- secured a Fullbright Scholarship to work in Florida on problems of dairy cow synchronisation. While in Florida, he develop protocols for the use of CIDR in the Florida dairy sector to overcome heat stress related reproductive problems (NZDE, 1990, p.27). Florida was not viewed by the researcher as a principal competitor to NZ producers, and Dr. M--- used the opportunity to forge links with leading USA reproductive researchers (NZDE, June 1988, p.61). These links promoted the use of CIDR in USA dairy systems research and inspired reproductive physiology programmes in NZ. Another aspect of these exchanges was revealed in a frequent sharing of procedures between Victoria, Australia and NZ. Though milk products from Victoria compete directly with NZ products, extensive information about reproductive aspects of the farm system were exchanged and judged to be of mutual benefit (NZDE, June 1992, p.9). A more ambiguous form of 'IPR leakage' occurred when NZ funded and developed protocols were packaged as internationally marketed synchronising technologies. Such was the case when Guatemalan CIDR distributors were first to register a treatment programme for anoestrus cows. This situation occurred as a consequence of the variability in regulatory requirements for animal remedies among different countries. Those countries with less restrictive legislation were capable of capturing a competitive lead on NZ, though correspondingly ran increased risks in relation to the reliability of the technology.

Competition to the synchronising service emerged in 1993. Veterinarians working on the development of synchronisation programmes for the distributor and manufacturer identified what they considered to be new opportunities for synchronising technology. The actors at the centre of the system's development work considered more trial work was required. A difference of opinion ensued resulting in the formation of a competitive service. The actors in the competing service had built networks with veterinarians in their role as system developers. They targeted veterinarians as the logical choice to compete against a larger and more established opponent in the synchronising technology market.

> *'The vets are the key influence in terms of who does what synchrony ... Yes we think that the veterinarian is the ultimate influence in what kind of synchrony package or what kind of management package that farmer is going to use and between them they will make the decision. I mean the philosophy we have, contrary to what a lot of people may think from the way we have done it over the last two years, is that we still believe that the veterinary profession at large are the right people to administer and provide those sort of services. What has to happen though is they need to upskill themselves. I think that process is taking place.'* (Competitor)

Competition stimulated efforts to develop new devices that electronically metered dosages, the formation of new networks and alternative reproductive management systems.

> *'... the CIDR device is very consistent. You put it in an animal, you pull it out and you know pretty well exactly what it is going to do. So again it has been our intent to try and make constant the process of synchronising so you put that process in a box and say provided you follow it a particular way you have got a reasonably good understanding of what it does. The problem was (and once you have got that in a box you can then focus on the important management issues that in fact have a greater impact on the outcome the problem) that because of the complex way that we had to actually deliver that process with the multiple injection process etc it was quite difficult to explain to the consultant at large the importance of delivering that process in one particular way to reduce the variability of the programme. So they could focus on the other management issues within this area of expertise, and we still have a problem with that.... What we are really trying to do though is go to the veterinarians and say here is a product for you to use. We will give you a whole lot of support information so that you are familiar with how it is used and provide it to your farmers. We provide you with all the tools you need in support of the product. We also have our own database of information and provide management reports as a consequence of getting information back and put all that back to the veterinarian for them to deliver'.* (competitor)

However, there was a sense of lost harmony among the actors in the theatre of innovation as a consequence of the divided effort in the sector in synchrony technology. A small commercial laboratory had formed as a rival to a well established and coordinated synchronising service, the latter having secured intellectual property rights in terms of patent rights on the device, and distribution rights for the device. Furthermore, this large competitor possessed a well established branded service. However, the competitive rub was most visible at the interface between the distributor and the competitor, the former having legal obligation to supply CIDR devices to its competitor, who then integrated these into their own programmes until their own device was developed and patented.

5.2 Critical Issues

A changing continuity in the emergence of synchronising technology was discernible as organisations continued to restructure, and as demands for the introduction of new tasks increased, which therefore prompted the introduction of new actors to commercialise the work of system developers. Commercialisation work in turn resulted in the CIDR programme becoming more visible within the sector, thereby attracting the use of regulatory activities by sector leaders and research management. Interplays within the club enabled a sharing of tasks and strategy that minimised the influence of regulation of the development programmes. Judgements about what constituted valuable IPR and the limits to its dissemination in large part remained under the control of the development workers.

Production conditions were favourably disposed to using synchronising technology in the first season of commercial promotion. Acute farming system problems that confronted farmers at the time assisted those who promoted the technology to align synchronising benefits with what farmers were viewing as potential system solutions. New system development opportunities like the anoestrus cow project were stumbled upon as the actors performed the task of aligning attributes of the technology with farm system needs. Aligning the technology with farm system needs prompted further development efforts to construct new methods and tools which in turn required an alignment between farmers, veterinarians and researchers working on systems development.

This interplay of practices became a development issue in itself as it influenced performances in the market channel (see Figure 4.3). Actors used strategies to gain access to resources and perform within their respective professional domains. These strategies used access to centres of power, like regulatory boards, to achieve their purpose and influence the activities of others. Judgements about the appropriateness of these influences were made according to the mission of each actor. Strategies included informing other actors in the channel, and involving actors who were previously outside the club in development activities. The club provided opportunities for collective strategies that were used to minimise risk to the commercialisation of the technology from regulatory interventions. Evidence of the effectiveness of these strategies was observed in relation to the management of IPR by those workers who were operating in the programme.

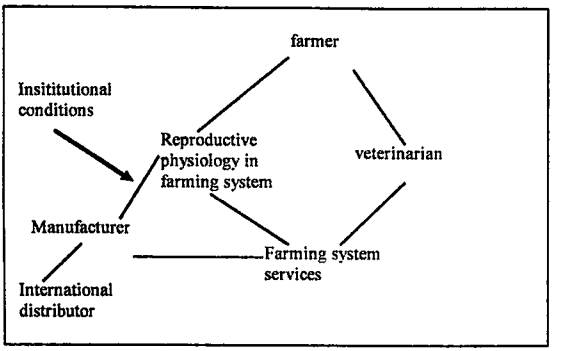

Figure 4.3 Significant actors in the commercialisation stage of CIDR

The issue of professionalism emerged as new actors entered the programme to construct new aspects of the synchronising technology. The veterinarians proved to be a significant actor in the theatre of innovation. Professional activities often involved some form of financial reward to the professional when accompanied by an accountability to the paying client. This accountability amounted to a risk situation for the professional, which increased as their activities became transparent to others. Close working relationships required a shared integrity that could enable doubt about one another's practice to be balanced with a trust in the professional, and the use of open procedures for decision making as a club. Competition introduced a new dimension to the issue of professionalism, particularly when the competing professionals emerged from within the club. This in turn raises the issue, were the latecomers to the club fully integrated, or was their zeal for the synchronisation technology not sufficiently balanced by the social integration of the new actors to the CIDR development work. Regardless, competition had a partially negative influence on harmony in the theatre of innovation and access to resources, yet fostered the establishment of a new programme to work on synchronising technologies.

5.3 Emergent Learning

During the commercialisation stage, the CIDR emerged as a synchronising technology that provided service through a process of continuous development. More actors were recruited into the programme to perform an increasingly diverse range of tasks. New methods of service were devised to cope with diverse problems encountered with different farm systems. This construction of new methods combined different types of hardware and monitoring procedures using protocols that specified the rules for action. In this stage synchronising technology was no longer a domain of expertise occupied by a few developers, it became a formal arrangement of rules for service - organised in terms of operating systems and regulations. The emergence of the technology again raised the problem of transition in terms of identity and ownership among the actors.

Consistent with prior stages, new development opportunities emerged not so much from foresight by the actors, as from recognition of possibilities that were apprehended by the actors as they performed.

Alignment of actors in the theatre of innovation was a development problem during this stage. The delayed inclusion of the veterinarians early in the development process resulted in tensions among actors and a lack of harmony in the theatre of innovation. The competitive actions of some veterinarians may have been a response to a sense of frustration at their lack of power to influence development, but failed to improve the harmony of the theatre of innovation. Furthermore development involved an increasing emphasis on financial transactions as actors performed a combination of service and development tasks. Commercial servicing accentuated aspects of risk management, with professionals being accountable for the reliability of the technology. When programmes of collective action for the development of technology extend to commercialisation, the partitioning of risks and financial rewards among the participating professions require sufficient interplay in practices for actors to support one another.

6.0 The CIDR in Contemporary Dairy Farming

6.1 Significant Events

By 1995 the CIDR had become common place in New Zealand dairy farming. After 20 years of development effort the manufacturing, farming and veterinarian profession had worked together and established well developed routines for using the device within an integrated synchronising technology. Furthermore, CIDR was opening a technical door for subsequent advances in new hardware and methods. Synchronising technology was continuing to change and evolve, though these changes depended on the CIDR, a device considered by some to be mundane, and by others a *necessary evil* - something they would prefer to do without if a more elegant option was available.

> *There are a lot of enigmas about CIDR. It's a technically inferior product. A lot of the science development has been done by this defacto R&D department of C---- on the side. Because it is a necessary evil, if it falls over the others go. It's what I call the technology pyramid.* (Scientist)

This section investigates how the synchronising technology was rationalised in terms of CIDR use while still moving toward the use of yet more sophisticated hardware and methods on farms. It is first necessary to trace back to the events that occurred chronologically in the previous section, but they are discussed in this section because of their contextual significance to experiences with CIDR in contemporary use.

Significant economic gains were demonstrated in field trials that compared farm systems using the device with traditional systems. Indeed, favourable economic analyses were a prominent feature of early articles on CIDR (NZDE, June 1987, p.33; June 1988, p.62). However, these economic assessments were simplistic in their handling of decision making under risk and uncertainty. From 1987 to 1992 veterinarians using the device were reporting far more variability in results than was suggested by the experimental trials. Arguments were put forward by developers that attention to all aspects of herd management was crucial to achieving acceptable results

from CIDR use. Heat detection, feeding levels and correction of mineral deficiencies were all put forward as important factors to manage. For example, through 10 years of literature there was a continual reminder to farmers to observe and record heats. Though economic and technical evidence supported regular monitoring of heats, it was not until tailpainting[5] became widespread that monitoring of heats became routine among dairy farmers. Cow condition and length of lactation were also targeted as potential factors affecting the results from using the CIDR. The quality of semen and the performance of the inseminators came under scrutiny too. In general it was claimed that a high standard of farm practice was necessary for farmers to achieve good results. Not that the scientists thought the farmers incompetent, on the contrary, in general the NZ scientist had a high regard for the NZ dairy farmer. This respect was mutual, with farmers and the sector frequently acknowledging the contribution from R&D to international competitive performance. CIDR use in the sector was influenced by this ongoing interaction among farmer and researcher.

> *"NZ herd owners have a well-deserved reputation for adopting and adapting relevant new technology. Utilising CIDR's to best advantage will be another example, provided the limitations of the technology are recognised."* (Macmillan, NZDE, Oct 1987, p.45)

However as performance problems continued to plague services involving the use of CIDR the developers began to distinguish between types of farmers, suggesting that some were leaders in the industry.

> *'In all trials we are fortunate to have the continuing support of a group of herd owners who share the work. They are 'industry leaders' in that they let new technology be tested and developed in their herds so that other herd owners can benefit from our research.'* (Macmillan, NZDE June 1990, p.88)

Variability in the performance of synchrony technology also motivated researchers and veterinarians to continue testing and refining service protocols to achieve reliable and profitable results over a diverse range dairy farm management situations. In a 1996 article, researchers commented on the anoestrus problems caused by the poor spring of 1995. The article was defensive of the research based protocols for treating anoestrus cows and acknowledged that there were many unkowns about anoestrus in NZ because it was a problem unique to the pasture fed dairy system (NZDE, 1996, April, p.92-3). Again the trial farmers were described as atypical individuals that continually questioned and learnt about their farm system by paying attention to the details of herd management.

One extensive study found that claims of economic benefit from using the CIDR on the lactating dairy cow was unsubstantiated in practice (Xu and Burton, 1995). The study challenged earlier claims that the CIDR achieved a 9% increase in pregnancy rates in lactating cows (NZDE, 1990, June, p. 86-8). While R&D colleagues argued and debated within their workshops, conferences and research journals, the farming media were reporting conclusions and decision rules. The CIDR protocols were based on a few trials and later modified by collecting and interpreting a multitude of field experiences. As more trial results and experiences were pooled, the rules of

[5] A method of painting the hind quarters of the cow with paint that is rubbed off by the simulated mating behaviour of cows during ovulation

synchronising practice using CIDR technology became more evident to the practitioners. The suite of services developed by the CIDR programme evolved to account for different classes of stock and for different management objectives. For example, the device was used to calve young stock earlier, to treat non-cycling cows, and to simplify the management of large herd synchronising by eliminating the need for oestrus detection. These refinements were achieved by developing resynchronising methods, and by combining the use of the device with other hormone treatments. The distributor marketed these services through the veterinarians to farmers as management packages which were protected by copyrights on brands and logos. As experience accumulated the number and complexity of management packages was reduced to focus primarily on the treatment of heifers and anoestrus cows.

The competing organisation also relied on the use of the CIDR device in its initial years of trading, but developed alternative market channels to veterinarians and had a copyright over its own branded management package. By 1995 this competing company was trialing an electronic prototype device that pumped a cocktail of hormones into cows over the reproductive cycle. A vast increase in the complexity of the device resulted in a vast reduction in treatment protocols, but at a price. Economic evaluation was proving to be an iterative task performed in conjunction with the continuous evolution of the technology. Both CIDR based management packages, and those using the new competitive electronic device, were changing in terms of their configuration of devices and protocols, and reliability in the farm system, that in turn required changes in investment behaviour by users.

There was a growing awareness among the actors involved with the synchronising technology that significant advances in new hardware had not emerged from the CIDR programme, despite an acknowledgment by all partners that opportunities existed for new technologies in reproductive management. What was to be expected as the next generation of synchronising technology? Increasingly the manufacturer adopted an in-house policy to perform R&D and manage channel alignment through the supply of information. This in-house development capability was enhanced when the wholly owned subsidiary company moved to new premises in 1995. Later, in 1996, the company was purchased by a North American company that placed further emphasis on in-house R&D. Meanwhile the systems researchers involved in the programme from the start of the systems development work considered the *fixed* royalties were not keeping pace with the continuous improvement approach to developing management packages. These researchers advocated the formation of a venture company that would develop new hardware, protocols and monitoring procedures for the dairy reproduction market by accessing capabilities across several organisations. For example, the Crown Research Institutes did not contribute actively to the development of the synchronising tools, but were pursuing other developments that would have an impact on the synchronising market:

> *'I raised this issue at a business meeting recently - and it is really being clear what business we are in. And I call it* ***successful pregnancy*** *- we are not in the business of producing embryos* per se *because that's no good to anyone. If we are in the business*

of successful pregnancies, the TDU[6] needs to ensure it's got synchrony protocols out there for recipient cattle - if those are CIDR's, then so be it, but it doesn't have to be CIDR..' (CRI Scientist)

A joint venture was eventually established in late 1996 that shared investment in a 50 cow trial herd between the manufacturer and the DRC, the latter receiving an increased royalty stream. The research company assumed responsibility for the management of all the animal testing, while the manufacturer's in-house R&D group assumed responsibility for the engineering of release technologies.

The commercialisation of technologies fostered new activities in research work. Scientists were now talking in terms of invoicing, discounting, intellectual property rights and clients as part of their normal work routine. Dependencies and interfaces characterised the interaction between research and commercial work that pursued a common development of technology. When do the developers in this commercial environment chose to compete rather than collaborate? Controlled Breeding technologies (CBT) is a term recently introduced as a way of initiating linkage among reproductive technologies developed across several organisations (MacMillan, 1996). This attempt at linkage was based on a premise that the actors in each practice shared a common understanding of breeding problems, but operated in relatively distinct domains of work in terms of competencies to address these problems. Embryologists, veterinary scientists and reproductive physiologists may yet link sperm sexing, embryo transfers and breeding aids like the CIDR in a comprehensive suite of technologies that are aligned for a variety of system needs. If this collaborative development occurs, it is likely to differ substantially from previous competitive developments that has seen the CIDR largely displace inductions, while successfully retaining a role in synchrony technology against attempts by semen capsules to displace the need for CIDR (NZDE, Dec p.54; NZDE, May 1994, pp.52-4).

6.2 Critical Issues

The CIDR device was integrated into routine farm practice by a muddling through process involving the combination of sense-making by veterinarians and farmers in the field, with systems research by scientists. This integration yielded new opportunities for the further development of reproductive technologies involving embryo work, sperm sexing etc.

In contrast to the contribution that the CIDR made towards an expansion of development opportunities, the refinement of economic performance assessment helped rationalise services and allocate resources to those services that evidenced most benefit to users. Demands by users for evidence of benefits applied to the services of the dominant distributor and its recent smaller rival. The cost of entering the synchronising market were high for the rival as the company was required to distinguish itself from the resident provider by developing new hardware that required considerable investment in development.

[6] Technology Development Units which were groups established within the CRI to commercialise technologies developed within the CRI.

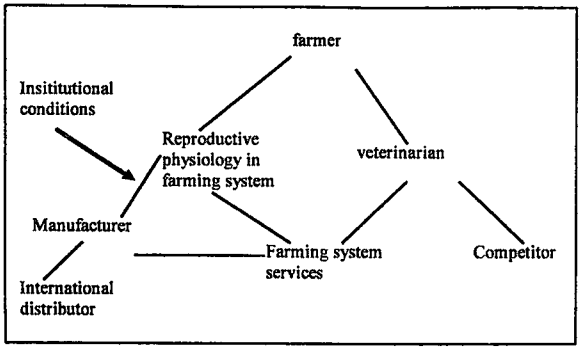

Figure 4.4 Significant actors in the contemporary use stage of CIDR

Collaborative work around the CIDR device built a network that became a resource for subsequent development effort. Actors appreciated the need to carry out deliberate activities towards the construction of closer economic ties among organisations. The use of formal arrangements like joint ventures imparted more flexibility to those actors that sought to work collaboratively with actors in other organisations. Formal joint venture arrangements were accompanied by informal ties like strategies for CBT that inspired technical linkage among practices.

6.3 Emergent Learning

Contemporary use of the CIDR has culminated in the device, initially the subject of development, undergoing minor refinement as actors' work shifted more to align components in a synchronising technology, and at a yet higher level, to construct a general reproductive technology. The device has shifted from that of a development subject to become a tool in a more encompassing development effort. New transition management challenges emerged. Whereas previous challenges related to the activities of actors, this stage required the capability to move the development focus into a new domain of practice. In particular, an ability to respond to feedback from other actors working in the domain of dairy reproductive management and adapt and align activities accordingly.

Competitive actions seek to make one technology a success by displacing an existing technology. In as much as a professional service may be tied to the hardware or methods comprising the incumbent technology, the displacement of that technology by a competitor represents a threat to the profession. Changes in the material and cognitive aspects of technology will have social implications. New power relations will emerge in the market channel as professionals either defend or advocate technology as competitive activity. These relationships may offer opportunities for new organisations to enter a sector. For example, an animal genetics company may supply venture capital to underpin competitive developments in synchronising technology as means of access into new markets. Competition may also stimulate constructive efforts to improve alignment among existing organisations. This

alignment can include formal organisational ties and informal professional ties around a common general practice like reproductive technology.

7.0 Conclusions

This case study represents the emergence of a synchronising technology in four stages. A continuity of change extended from early development efforts to build a device that was later commercialised as the CIDR. The use of CIDR by veterinarians working with farmers generated a new class of problems that stimulated further development. The history of the CIDR provided evidence of an interplay among practices. The various aspects of practice, including the construction of work methods, material changes in the device, and (re)alignment of actors were so interwoven in the emergence of the technology that change in any one aspect had implications for the others. For example, changes in the configuration of the device had implications for how the device was used (protocols) and who performed with the device (technician or veterinarian). This property of emergence implies that knowledge content cannot be divorced from an analysis of the interactive routines that actors use when they construct knowledge in a theatre of innovation.

Alignment among actors in the CIDR development was a significant issue. In particular, the delayed involvement of veterinarians could be linked to subsequent development problems. A respect for the veterinary profession was shared by some but not all of the actors in the theatre of innovation. This issue of respect for collaborating workers was considered particularly important in knowledge intensive practices, like those performed by the veterinary profession, and operating in technology development. Fostering interplays among practices can go some way to engendering respect among actors as they work together on development problems. As actors work together to discharge a common performance they are privileged to experience windows of insight on the competencies operating within each practice. This may be the finest opportunity any one actor may experience to appreciate the practical world of another. With the commercialisation of the CIDR the largely intangible realm of shared practice gained a tangible counterpart in the formation of rules for the exchange of finances, intellectual property rights and other material assets. The social aspect of practice interplay was observed in the formation of clubs among the actors working on the development programme. The club could perform collective strategies that were in the interests of its members. The strategies of clubs can have positive and negative consequences for the emergence of technology. Positive in that resources and accountability are tied to the actions of members, and negative when a club becomes introverted, denying access to new members who may be essential for emergence.

Working towards an emergence of technology involves changes among the actors performing the work in the development programme. As new devices and methods were constructed, new problems were encountered that tended to widen the scope of the programme from the commercialisation of the CIDR to the emergence of synchronising technology. A comprehensive array of devices, methods and constructs was evident in the performance of synchronising practice, and at a higher level,

reproductive management. **The technology emerged as a practice over time**. The device and protocols embodied rules of the game, and the actors developed strategies using rules of play (use feedback from other actors). The different aspects of practice performance changed in relative significance to one another over the development history, but they were always a unity. At one time it might have been rapid changes in protocols that influenced the alignment among actors (farmers and veterinarians) and changed the composition of the device (no longer use Cidirol). At other times changes in the device may have precipitated changes in the other aspects of practice performance.

A process of muddling through towards an emergent technology was evident in each stage of the development. This process was characterised by actors working on problems that emerged as a consequence of their previous development activities. Muddling through has leadership implications for technology management. Leadership may be more effective when performed as an appraisal of opportunities that provide some license to the rebellious activities of some individuals, particularly in the early stages of development. Both Dr. W--- and the systems development club were given sufficient flexibility to perform work that may otherwise have been stifled under a more stringent management regime. This suggestion implies that the use of formal planning routines may have limited applicability to the management of technology. However, it also implies leadership ought to be vigilant about maintaining what amounts to an emergent profile for the technology, continuously working to improve the clarity of purpose and direction of development programmes, and plumb the conceptual depths of workers as they reflect on their activities.

Amid the frequent organisational changes evident over the developmental history of the CIDR, a continuity in the emergence of the synchronising technology was observed. This continuity may provide an opportunity to improve the alignment among actors that may otherwise experience displacement and a loss of identity through frequent organisational change. Furthermore, the notion of technology as practice may provide an opportunity to cross organisational boundaries that would otherwise prevent effective collaboration in the theatre of innovation. A new organisation may set out to build a sense of corporate identity, but in a competitive environment these activities may unwittingly reinforce boundaries between potential collaborators. However, interplaying practices would permit actors to work together regardless of their organisational ties. Problems of ownership with respect to IPR would be resolved by a process of muddling through, as no IPR would exist at an early stage of development. As a technology emerged out of the work of interplaying practices, an accompanying muddling through process would work towards the development of formal arrangements like joint ventures that were well aligned with the requirements of practice. The arrangements would be well aligned because they would emerge out of the interplay. This raises a further question, who is performing as manager, as each organisation has vested interests, as do clubs of actors? This question will be explored further in the following case study.

Chapter Five

The Emergence of Mastitis Management: A case study of the SAMM programme

> *'New Zealand dairy research is recognised as having made an enormous contribution for decades. I have witnessed the near destruction of milking machine and mastitis research in the United Kingdom and other countries. The NZ industry is facing the same problems but is constructing a system in which the industry and government researcher work closely together. I believe that is a powerful and correct approach and I wish you well with it.'* (Bramley, 1991, p.13)

1.0 Introduction

This case study represents the changes in the way mastitis is managed on NZ dairy farms in four stages. The discussion of each stage provides an account of the emergence of mastitis management for NZ dairy farming conditions. In a period spanning three decades, a general programme, based on technology developed in Europe, was introduced and repeatedly modified by various organisations to finally achieve an economically integrated intervention for the production of raw quality milk. A brief description of the first three stages culminates in the launch of the SAMM, an intervention that promoted management procedures for the reduction of mastitis in the national herd. An investigation of the events leading up to the emergence of SAMM will respond to the question that emerged out of the CIDR case study, viz.: who manages change in a practice when each practitioner operates with vested interests? This question can be reframed to address a more general problem relating to the management of interventions, viz.: how is a sector-wide intervention worked out by the actors and organisations operating under free market policies?

This chapter opens with a review of mastitis as a management issue in terms of the decision context and problem domain for NZ farmers. Significant events that influenced the change in mastitis management methods for the national herd are described and explored in terms of critical issues and emergent learning in response to the above question. Conclusions from this study raise further questions that will be investigated in the subsequent and final case study.

Several organisations and individuals have participated in sector efforts to improve mastitis management using intervention programmes. Figure 5.1 is included to assist the reader to identify the intervention programmes, organisations, actors and practices operating at each descriptive development stage.

Development Phase	Intervention Programme	Participating Organisations	Actors (champions)	Practices
General Programme	5 point plan [learning]	MAF (National Milk Quality Scheme)	Mr D—, Mr T—	systems service; analytical service
Establish Monitoring	SCC service [learning]	LIC; Massey; MAF (NDL); Dairy cattle vets	Mr H—; Dr M—; Dr H—; Mr D—; Dr J—; Dr S—	Vet service; systems service; systems research; analytical service
Modified General Programme	5 point plan [learning] + ICSCC	LIC; Massey; NDL; MAF	Mr H—; Dr H—; Mr D—; Mr E—; Dr M—; Dr S—	Vet service; systems service systems research; analytical service; vet research; machine research; shed management
Specific Programme	SAMM [learning + incentive]	LIC; DRC; NZDB; Massey; SAITL; MAF; NZDG; AGCALM; Dairy Vets; Farmwise; MPTA	Mr H—; Dr H—; Mr D—; Mr E—; Dr M—; Dr S—; Dr S—; Dr W—; Mr D—; Dr H—; Mr F—; Mr R—.	Vet service; systems service systems research; analytical service; vet research; machine research; shed management quality mgt; Agchem mkting

Figure 5.1 Stages and Participants in the Development of Mastitis Management

2.0 An Overview of Mastitis

An economic analysis conducted in 1992 estimated annual losses to the NZ dairy sector due to mastitis infections of $33 million, implying an average loss of $2200/farm, or $15/cow (NZDE, 1992, p.6-7). These losses were incurred as a consequence of reduced production and a decline in milk quality. Bovine mastitis is an inflammation of the mammary gland (Dodd, 1987). Inflammation can arise from infection, traumatic or toxic causes. In NZ most inflammation results from pathogens

entering through the teat canal and infecting the udder quarters. Bramley (1991) notes that more than 30 types of bacteria, fungi and mycoplasma can cause mastitis, though under NZ farming conditions 2 bacterial species are of most concern. *Staphylococcus aureus* is responsible for most infections during lactation and is classified as a contagious pathogen (Williamson *et. al.* 1993). *Streptococcus uberis* is the predominant bacteria infecting udders during the dry period and is classified as an environmental pathogen. Environmental pathogenic bacteria contaminate teats from sites that expose udders to cattle faeces and contaminated water, like poorly managed feeding pads.

Dairy cows possess protective mechanisms to combat teat invading pathogens (Eden *et.al.*, 1992, p.42[1]). During lactation the sphincter seals the teat opening to provide a physical barrier to pathogen entry. Antibacterial substances in the teat canal provide a second line of defence against micro-organisms that may have entered the teat before canal closure. An additional defence is provided by leukocytes that surround and isolate micro-organisms to prevent infection of healthy tissue. As cows approach drying-off, a keratin plug forms to seal the teat canal during winter.

Cows that suffer from mastitis release somatic cells into their raw milk. Somatic cells are the cells that make-up an organism. High somatic cells in milk can result from udder infections, or from a general virus infection of the cow. A third source of increasing somatic cells is environmental stress that increases corticosteroid levels (Schreinemakers, 1991). Somatic cell counts (SCC) have been used to indicate mastitis infection, however the multi-dimensional attributes of mastitis, combined with the multi-dimensional factors responsible for increasing somatic cells, result in correlations between high SCC and mastitis infections of between 0.6-0.7 (Westgarth, 1975, p110). As will become evident in later discussion, the uses of SCC had implications for both the development of management methods, and for the regulation of food safety.

Pasture based dairy farming in NZ requires farmers to align seasonal variations in feed supply with physiological variations in cow feed demand, while optimising milk production. The systems that farmers' used to achieve this alignment increased their need for a NZ based mastitis management programme (NZDE, 1992, Dec, p6-7). The next section investigates a series of intervention programmes launched in NZ to derive a common practice for mastitis management.

3.0 A General Programme

3.1 Significant Events

During the mid 1970's Mr D---, having recently arrived from England where he worked on mastitis research, was employed by MAF in the National Dairy Laboratory (NDL). In the course of his work in NZ he was exposed to milk harvesting methods and dairy shed hygiene. He became concerned with what he considered high levels of mastitis in the national herd, which he considered was responsible for excessive

[1] Eden, *et al.* 1992, Managing Mastitis, a practical guide for the NZ dairy farmer, LIC.

economic loss to the dairy sector. Mr D—'s work in the UK had introduced him to developments on the 5 Point Plan, an intervention programme developed in England for improving the management of mastitis in dairy herds (Wilson and Kingwill, 1975).

The first national intervention programme targeting mastitis management was launched by MAF in the mid 1970's, being the 5 Point Plan as developed in England. Farmers could control mastitis infections using the 5 Point Plan when the causal pathogens were contagious (*S. aureus*, and/or *Streptococcus agalactiae*). The plan used a combination of treatment measures, viz.:

1. teat disinfecting
2. dry cow therapy
3. treatment of clinical cases
4. culling of chronic cases
5. milking machine testing.

Particular emphasis was placed on teat disinfecting in the plan as a preventative mastitis control procedure performed during the period of lactation. The teat disinfectant (usually iodine based) was mixed with an emollient like glycerine and sprayed onto the teats immediately after cup removal. Exactly how teat disinfectants work to control mastitis was not known (Eden *et.al.*, 1992, p.63[2]). However, in a survey of NZ dairy farmers' perceptions of effective methods for mastitis control, teat disinfecting was the only method associated with reduced somatic cell counts in milk (Laycock *et.al.*, 1987, p63).

Dry cow therapy, the treating of clinicals and the culling of chronic cases are curative methods for treating mastitic cows. Dry cow therapy (DCT) is, '*the intramammary infusion at drying-off of an antibiotic formulated to have a long acting base with a release time extending over a period of weeks.*' (Williamson, *et. al.* 1993, p.65). The effectiveness of DCT depended on the species of bacteria and severity of infection treated at drying off.

Farmers could employ veterinarians to sample for bacteria species before selecting the type of antibiotic for DCT. Under the 5 Point Plan, the decision to cull was recommended as a last resort for chronic cases.

Finally, the testing of milking machines addressed those attributes of the machine that exacerbated infections. In particular, those attributes that resulted in extended milk-out times which tended to damage the cow teat, viz.:

1. vacuum level: high vacuums could cause teat damage, particularly when cows were over milked;
2. pulsators (the open/shut valve that rested the teat between suction cycles): when faulty, dirty or incorrectly adjusted could cause teat damage;
3. liners: when incorrect liners (length or mouthpiece diameter) were used they could cause direct physical damage of the teat or lead to liner slip and subsequent teat damage.

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[2] ibid.

The principles embodied in the 5 Point Plan were communicated by the MAF to farmers using extension innovations like the distribution of an LP recording, 'Mastitis Melodies', and the performance of a nation-wide stage show that dramatised the mastitis management methods advocated in the Plan. These innovations were complemented by more conventional extension methods, including the publication of feature articles in journals, fact sheets and radio talks. Formal evaluation of the programme was not undertaken, but an increase in the use of teat spraying and DCT were thought to have resulted from this initial programme. The 5 Point Plan became a common term in the dairy sector, even if farmers varied in the way they used the messages from the Plan in their farm management. After three to five years, Mr D--- became increasingly concerned that communicating the general principles embodied in the 5 Point Plan was insufficient to improve the management of mastitis in the national herd. His concerns related to the non-specific nature of the recommendations, and that the programme did not adequately treat mastitis in relation to the seasonal nature of NZ pasture based farming conditions. He considered a monitoring scheme, that enabled farmers to observe their herd infections and respond accordingly, was necessary to underpin further improvement in mastitis management.

3.2 Critical Issues

The movement of actors like Mr D-- enabled the transfer of the rules of mastitis management be replicated as methods in NZ. The working experiences of Mr D-- meant he embodied aspects of a mastitis management programme that then sensitised him to opportunity for a similar programme in NZ.

Methods in the programme were limited to the management of the contagious bacterial spectrum, and typified general responses to mastitis infections. Successful control may have been achieved by attacking infections on several fronts, but actions were often associated with control without causal explanation, as in the teat spraying situation. The programme also emphasised curative procedures that tended to address the problem of mastitis after the infectious event, rather than the anticipation of infectious periods and accompanied with methods of herd protection.

Depending on the farmer, several practices could interplay around a mastitis problem on a farm using the rules embodies the 5 Point Plan. Attention to animal health, milk-harvesting and milking-machine design and maintenance, at times required the services of veterinarians, engineers and consultants. The 5 Point Plan therefore acted as a interface for the interplay of practices around the problem of mastitis control. The innovatively communicated messages in the plan were delivered by professionals with a working knowledge of mastitis. This interface was farm specific, directed by the farmers as they worked out the implications of the 5 Point Plan message for their local situation. As farmers used the general rules specified by the Plan in practical applications on their farms the professionals in the programme were alerted to the need for monitoring to improve the targeting of methods to infectious problems and assist the adaptation efforts of farmers.

3.3 Emergent Learning

At the time the 5 Point Plan was introduced to NZ, no one profession claimed mastitis management to be their domain of work. This may suggest that the novelty of the message (and accompanying medium) was combined with low levels of conflict between professions because the programme was developed *outside* the sector. Using the programme in NZ required a mediating actor who worked on the development in the UK and therefore embodied the rules of method, or ways of *doing* mastitis management, that it was possible to design and adapt messages to NZ conditions. The 5 Point Plan specified general rules, as ways of doing mastitis management, leaving the working out of specific detailed procedures to be an adaptative performance operated on individual farms. It was as this adaptation to NZ conditions was performed that the limitations of the outside programme were identified. These limitations can promote new adaptive responses and the emergence of new initiatives.

4.0 The Development of Monitoring Methods

4.1 Significant Events

By the late 1970's workers in Livestock Improvement (LIC) were considering the expansion of herd testing services to include SCC. In NZ, herd testing uses data collected from individual cows that aligns production with breeding attributes to guide subsequent breeding decisions. Herd testing is not compulsory for farmers, the service is obtained at a fee, but herds that have been regularly herd tested and have attained high breeding indexes, tend to attract higher prices at stock sales. The workers at LIC recognised the importance of developing monitoring procedures that assisted farmers to determine the incidence of mastitis in their herds, to guide decision-making in relation to mastitis management (Arnott, 1982; Hook, 1982; MacMillan & Hook,1982). To develop monitoring procedures required the use of SCC hardware and methods. The conventional international approach to SCC involves sampling of Bulk milk (BMSCC). The LIC workers sought to improve mastitis detection by developing monitoring methods that would enable the testing of individual cows (ICSCC). These ICSCC were to be part of a herd testing service operated by the LIC (Hook, 1982). Often the actors who shared in the development effort possessed a joint enthusiasm about new possibilities for managing mastitis. This enthusiasm was accompanied by a respect for the work of others, and the recognition by any one actor that their performance depended on the work of others to achieve their shared outcome.

> *You have to have the visionaries. I'm not taking any kudos for it, it's just the bent I have, and a lot of the time you get proved wrong because you are not scientifically based, but it has let me go down tracks because nothing constrained my thinking. I had enough knowledge to be dangerous, but you have to have that opportunity to share with others to cover yourself.* (Service Champion)

To develop and promote the service LIC staff, who were skilled in the development of services to farmers, worked with the MAF staff involved in the 5 Point Plan programme, and a private company that lent analytical equipment during the service development period. Service refinements were achieved by introducing improved analytical equipment (thereby lowering costs to farmers) and by linking with veterinarians and advisors.

> *An early realisation was that accompanying the introduction of such a service there should be promoted a clear understanding of the use of the data and interpretation of results by farmers and their veterinary advisors. We have been heartened by the attitude of a high proportion of veterinarians in practice in our area to the service and how it can be used.* (Hook, 1982, p.104)

Collaboration with animal scientists at Massey University completed the interplay of practices necessary to establish a monitoring service. A Massey publication, referred to as the yellow book, became the definitive work in NZ on SCC and was used by programme champions to justify further development of a SCC service contrary to criticisms from within LIC that such a service had no place in the low cost NZ dairy system.

> *'We even had terrific problems within our own organisation. Even when I came here 12 years ago, we still had leading people in this organisation saying we shouldn't be providing that service. When the organisation was reformed the restructuring committee came to me asking, "why is there so much back biting about this SCC service?" I replied it's a little bit of it isn't invented here. I have gone to outside people and involved them without necessarily involving our own R&D. I have looked at other things that haven't been in the priority of our own R&D guys. I have got other research done outside by involving supporters and their organisations like the J-- M---, and the I-- S--, and the C-- H---, they have freely given me of their knowledge and encouragement.'* (SCC Service Champion).

At the time, LIC operated as 6 autonomous regional offices with a loose national affiliation. This organisational structure enabled the lower North Island office to press on with service developments by combining contributions from several practices not then available within Livestock Improvement.

4.2 Critical Issues

The development of mastitis monitoring methods benefited from an existing servicing framework that could be adapted to provide an individual cow monitoring service. Furthermore, an economic incentive for farmers to use the service was evident in stock sales. The monitoring needs that emerged from experience with the 5 Point Plan were aligned with the interests of the LIC workers' interests to complement existing services to farmers.

The actors were aware of advances in the hardware for monitoring SCC and were capable of linking these developments with their needs in the NZ dairy sector. Alignments in the social aspect of practice were also evident, with actors combining a inter-dependence in work performance with a social attraction and mutual enthusiasm. Taken together, the actors had sufficient confidence to develop new monitoring methods (ICSCC) for NZ conditions.

Development was a continuous process, with ongoing refinement of monitoring methods made possible by the introduction of new hardware and the interplay practices. Academic research performed an important role by specifying, through writing the *Yellow Book*, the internationally agreed rules for mastitis management that then enabled the service developers to justify their activities to others. Development

was also assisted by the organisational flexibility of the decentralised decision making and resource allocation procedures.

4.3 Emergent Learning

Under some situations, unrelated domains of work, like managing mastitis and herd testing, can align when actors' practical concerns can be generalised to a common level. This generalisation is possible when power plays among actors are not exerting a negative influence on the work programme. No one profession claimed mastitis management as their professional domain.

When actors' perceptions of their work domains are favourably disposed towards collective action, and organisational and social conditions are similarly supportive, the innovative development of new technologies like monitoring should be possible. Furthermore, the development effort ought to benefit from a constant searching for solutions to impediments throughout the life of the programme. This search routine may encompass the investigation of advances in hardware, assessments of professional dependencies and anticipating necessary activities (like the preparation of the *Yellow Book*) that will minimise resistance to the development outcomes. In all this, the energy and ability of individual actors may well determine the fate of the programme.

5.0 A Modified General Programme

5.1 Significant Events

At a practice level interplays were emerging, albeit in a rudimentary way, between the development of the service for farmers and research on milking machines. An independent, but ultimately complimentary programme to the earlier development work, involved researchers' efforts to develop new milk harvesting systems (Woolford, 1989). One objective of the milking machine programme was the development of protocols for the use of new tools, like conductivity meters to monitor mastitis infections (Woolford & Williamson, 1982, p.114). The expectations of researchers were focused on an in-line monitoring tool for use in dairy sheds that would provide real-time individual cow monitoring. The research programme's intention was to develop new milking machines as a collaborative programme between commercial engineers and government researchers. The problem of mastitis detection connected the research programme with the service development programme. Work on mastitis management now spanned three practices in the dairy sector:

1. managing cow health: primarily the province of the veterinarians
2. managing lactation: a shared domain including veterinarians, shed inspectors and consulting officers
3. managing milk harvesting: primarily the domain of shed inspectors.

While developments in the monitoring service were providing farmers with a means to improve their mastitis management, researchers were attempting to revolutionise current practice by developing a new means of milk harvesting. The problem of

monitoring mastitis became an interface for farmers, professionals and researchers to work together on issues of milk quality. Development work at the interface was encouraged as marketers and product certification agencies became increasingly aware of milk quality as an issue for market access (Smith and Hill, 1988). The introduction of market access considerations, such as a threatened introduction of EU regulations on high SCC in raw milk, prompted linkages among those practices working to manage mastitis, and those involved in managing milk quality beyond the farm gate. A special meeting of actors working on issues relating to managing raw milk quality, convened by MAF, was held in 1988 to specify what constituted quality raw milk and what testing programmes should operate in the dairy sector (Fawcett, 1989). The meeting coincided with changes in MAF responsibilities towards quality management of NZ export agricultural production.

Consistent with free market policies, central government reduced its involvement in quality management by transferring responsibility to monitor product quality to the sector producers and processors. Managing the risks associated with product quality became an increasing concern to the dairy companies (Franks, 1996). Sector interest in improving the control of mastitis expanded from a need to reduce costs of production resulting from lost yield, to the development of a national mastitis management practice that delivered consistent high quality milk at least cost. This expanded need stimulated government research effort from Ruakura applied at the level of farming, and veterinary research at Massey University (Holmes and Woolford, 1992). Several organisations were now working on different mastitis management issues, some of which assisted with the development of a monitoring service. In particular, an appreciation of the need to develop specific seasonal management procedures under NZ farming conditions. This need was expressed in terms of economic loss to the sector, thereby countering a general threat of reduced R&D funding for dairy production research (NZDE, 1992, p.6-7). Furthermore, the revenue generated from farmers' purchasing of herd testing services, provided additional funds that enabled the international expertise on mastitis to be accessed.

Figure 5.2 indicates that during the 1990's a number of professionals were involved in supporting the efforts of farmers, processors and marketers to create an image of 'The Worlds Finest Quality Milk' (Joe, 1993).

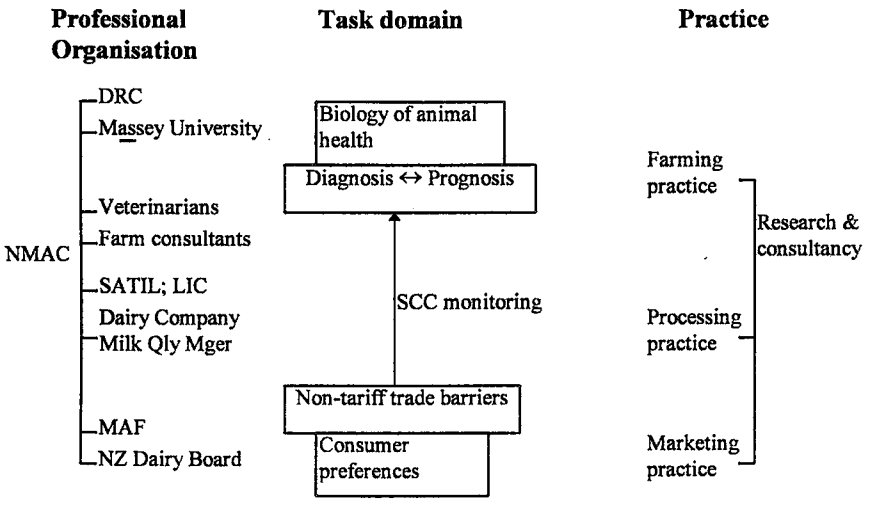


Figure 5.2: Professions Involved in Mastitis Management

Sector plans to improve raw milk quality were the responsibility of each dairy company with a general strategy for market access being the responsibility of the NZDB. Both the companies and NZDB turned to researchers in the hope of identifying opportunities to change farm methods and lower SCC in the national herd. Researchers in NZ in turn collaborated with their international colleagues to frame the problem of mastitis management under NZ conditions (NZDE, April 1991, April p.77; NZDE, June 1991, p96.) The influence of international researchers on the research programme at Ruakura coincided with an organisational initiative by MAF to link government and commercial researchers in a common organisation. The Dairy Research Corporation (DRC) was formed in 1991 with 50:50 shareholding by the government and the NZDB.

A second, but equally important organisational development was the emergence of the National Mastitis Advisory Committee (NMAC). Work on the development of the monitoring service had aligned actors from various practices and organisations. Over a 20 year period these actors had regularly met as an informal group to discuss aspects of mastitis management. The situation in the sector in 1991 was conducive to a more formal organisation of this group following the government move to place the task of risk management on sector organisations like the NZDB and the dairy companies. With no singular organisation responsible for funding or providing research and advisory services on mastitis management, the NMAC had no competitive structure trying to take a dominant role in sector programme initiatives. The NMAC received a sector mandate by default to co-ordinate mastitis management, being the only committee that co-ordinated the various actors involved in managing mastitis. A National Committee was therefore established under an LIC secretariat, to act as a co-

ordinating interface. Membership of NMAC included farmers, veterinarians, consulting officers, regulatory authorities, researchers and testing laboratories (Eden *et.al.*, 1992, p.3).

> *You get the disciplines whose opinions are respected, they are the professionals, and if they say , 'no that is wrong', they can kill a lay-person's enthusiasm. But our movement, because we had a hang of a lot of farmers who were also enthusiasts and they had political power, and we got that mass to overcome the reservations of the disciplinarians. We got our farmers to say, 'hang on, we have to do a bit more here, we are not going to take that as gospel.'* (NMAC member).

The NMAC was consistent in its representation of mastitis management issues and displayed leadership through the absence of any other body advocating improved practice. At times the NMAC adopted an aggressive marketing strategy, and at other times an interactive strategy with the actors involved in mastitis management. Decisions on which strategy to use, when advocating how mastitis ought to be managed, were an outcome of regular monitoring of the organisations represented on the committee. This monitoring was achieved through the professionals in the NMAC, who fed-back to the committee how their respective professions were coping with mastitis problems, and what technologies were deemed useful in the field. The NMAC was founded on the tradition of collaboration that formed around the task of building a robust monitoring service. When combined with conditions in the sector that were favourable for alignment and government policy that created a need to manage sector risk the NMAC enabled the actors in the sector to work out and endorse what constituted 'good' mastitis management. Publication of *Managing Mastitis - a practical guide for NZ dairy farmers* provided farmers with access to the most comprehensive documentation of mastitis management practice in a NZ context (Eden *et.al*, 1992, pp112). The book typified the NZ emphasis on practical knowledge generated by a collaboration of researcher and field based professionals who interacted with farmers around the problem of mastitis management. Published by LIC, the book was a product of the NMAC and funded by revenue from the SCC service available as an adjunct to herd testing.

Shortly after its establishment, the NMAC confronted a problem of conflicting advice from professions on managing mastitis. This conflict began to emerge as a problem for farmers who were confused with conflicting information on mastitis management (NZDE, Apr 1992, p.15-17 cf. NZDE Jan 1992, p.11).

> *Another one [*difference in professional advice*] was partial or full insertion of the canula on the end of the DCT. Some people said it must be partial insertion, and others saying full, and we had to agree that SAMM was the authoritative approach. In the first year of SAMM we got a small sub committee together representing all factions in the industry. We said we had to cease these mixed messages going out to farmers, what we want is an undertaking that you now go out with this version according to SAMM and you go to your discipline and say this is what we will do. If you can come back and convince us [NMAC] that there is a better way to do it, we will consider it, but you tick this off now that no one in your discipline should be permitted to preach a different story. That has been the most important thing about SAMM. Farmers up to this stage were saying someone tells me this, and another tells me that and it gave them an excuse not to take notice of mastitis management. We had to lock them in [the professional services].*
>
> *... It was great we had the NMAC committee because we had already started to achieve a role in the sector, at the time the researchers wanted us to take over the administration of SAMM, because we had the representative of the vets, the drug firms*

> *etc. and we charged them to go out and monitor what their people were up to. We brought the people in from the milking machine companies because there were some arguments going on there.*
> *... there could be many lessons that other problems could be dealt with the same way. Perhaps there ought to be a getting together for bloat or infertility problems to be dealt with in the same way. What we have done is have all those disciplines to get into 1 forum and said now this is going to be the agreed upon industry strategy for dealing with mastitis.* [Secretary, NMAC]

At about this time a visiting research fellow at the DRC was advocating change in the way the mastitis management programme was operating in the sector. Inspired by the research fellow, a small working group formed within DRC and developed a programme they termed the SAMM, or Season Approach to Managing Mastitis. The SAMM revised the rules in the 5 Point Plan using results from NZ research, and aligned these rules in a formal planning process thereby integrating what the researchers deemed important elements from prior programmes. SAMM was launched the year following release of *Managing Mastitis.*

5.2 Critical Issues

Some of the independent research programmes, operating at the time the monitoring service was developed and in use, had connecting aspects to mastitis management, even when the latter was not the substantive concern of the programme. These connections, like a common desire to use conductivity meters in milking sheds for real time mastitis monitoring, assumed an increasing significance as the domains of mastitis management expanded to encompass aspects of cow health, lactation management and milk harvesting. Each of these domains of action had allied professions, though no one profession assumed a unifying responsibility for mastitis management.

The research programme on milk harvesting could be compared with the programme to develop the monitoring service. Whereas in the monitoring programme actors sought to combine contributions from several practices to refine mastitis management, in the researchers' programme they sought to revolutionise practice by changing the rules of milk harvesting, such as the making of animal health decisions in real time using in-line conductivity meters. The problem of managing mastitis emerged as a consequence of the interplay of practices like animal health, farm management and milk harvesting.

Economic incentives also provoked further alignment among actors. Issues of market access, combined with the diminution of the government role previously performed through MAF to manage some overall sector risks, and the consequent demand on actors to take responsibility for food safety, provoked a heightened awareness of the need for collective action to reduce SCC in the national herd. As no single actor or organisation encompassed or represented the overall interests of the sector, an informal group (NMAC) became a mediator between the professions to specify what managing mastitis ought to be. The heritage of NMAC was an asset to the sector, in that those professions that were active in managing mastitis were members of the group, a group viewed by the professions as politically neutral in the sector, but

dedicated to a fundamental improvement in mastitis management. Funding the operation of NMAC was derived from a levy on the monitoring service. The NZDB, through LIC, therefore ensured the NMAC would continue as an independent interface for advancing the management of mastitis. Furthermore, the NZDB also entered into a formal organisational agreement with government to fund and provide research into aspects of dairy production, including mastitis. The combination of formal and informal organisations contributed to more formal sector planning and more co-ordination of mastitis research priority setting. The scope of this planning extended to mastitis management issues that encompassed farm, processing and marketing activities.

The first test of the NMAC, as a mediating influence in the sector, came with the conflict between professions working in consultancy practice. As with the 5 Point Plan programme, it was the influence of an actor from outside the sector that provided an inspiration for the alignment of several aspects of mastitis management practice into one programme, SAMM, that enabled NMAC to resolve the growing conflict in the sector.

5.3 Emergent Learning

When no unifying practice operates in a sector, and economic conditions operating on the sector are accentuating the need for such a practice, the professions may work to align their activities. This alignment will depend on the maintenance of sufficient distinction between the professional domains of action. It is where the domains of professional action overlap that conflicts are likely to emerge. Unification emerges as an overarching practice that does not undermine the performance of individual professions. Connections between practices can emerge when a need is shared to access new hardware or practitioners share a need to develop new operating methods. Whatever the connection, it is the problem as an emergent property of interplaying practices that simulates further practice interplay - interplay becomes a self-fuelling process. When political tensions among actors in the sector are low, the self organising nature of practices to align appears to succeed.

Formal and informal organisational frameworks can enhance a sector wide performance that attends to problems like managing mastitis. This enhancement derives from the provision of an interface for professions to work out an alignment on what constitutes best practice. In the NZ situation the NZDB was the organisational vehicle that resourced the informal organisation (NMAC) through the LIC. The provision of resources for informal organisations may not be necessary for such organisations to form, but they are likely to underpin the continuity of such organisations through periods when there is minimal need for the provision of an interface in the sector. However, when a new problem emerges, such as concerns about risks of antibiotics in milk, the sector will likely benefit from the continuance of the interface that NMAC provides.

The use of conflict in a theatre of innovation presents a management challenge to informal mediating organisations like the NMAC. In the case of the NMAC, conflict in the theatre of innovation was managed by using the development work of

researchers, work that was inspired from an actor that was outside the NZ Dairy sector. Was this an avoidance of responsibility because of an inherent inability of mediating organisations to resolve professional disputes, or was it a consistent and successful performance for an entity like NMAC? Just how does an entity like NMAC perform? This question is explored in the following section.

6.0 A Specific Programme

6.1 Significant Events

The SAMM programme was launched in 1993. SAMM provided farmers with a formal planning procedure to manage mastitis. The programme was an intervention initially developed in the DRC and later modified and extended to the NZ dairy sector through the professions that were members of the NMAC. Actors worked to develop a programme that provided the sector with a common way to manage mastitis. Their way of achieving common management methods in the sector was to reduce a complex problem into a practical planning sequence that would enable farmers and supporting professionals like veterinarians to integrate multiple technologies.

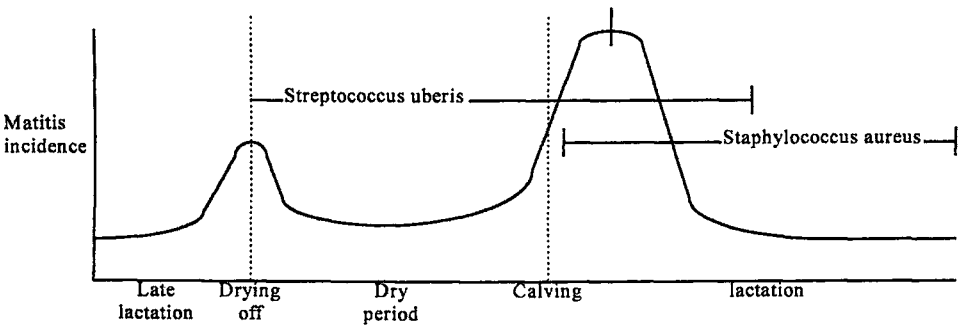
The SAMM programme goal was to have the sector, '*produce the world's finest quality milk by reducing the NZ national average bulk milk cell count to below 150, 000 somatic cells per millilitre of milk.*' (Joe, 1993, p.72). The design of SAMM stressed the importance of seasonal management of mastitis under NZ conditions. Planning activities were based on information contained in *Managing Mastitis* and targeted 5 periods in the dairy calendar, viz.:

1. late lactation
2. drying off period
3. dry period
4. calving period
5. lactation period.

Interventions in the NZ dairy sector for mastitis management had professionals providing formal knowledge resources (a book of facts), and researchers developing a planning programme based on the practical experience of researchers, professionals and farmers. Whereas *Managing Mastitis* was written primarily by field-based professionals with some input from researchers (the chapters on international mastitis research and tests for detecting subclinical mastitis), the SAMM was designed primarily by researchers with considerable collective effort by professionals in the development and implementation of the intervention (NZDE, Aug 1992, p.17; NZDE, Dec 1992, p6.). SAMM utilised the teat end protective mechanisms of the cow, and targeted control procedures according to seasonal variation in populations of pathogens causing mastitis (see Figure 5.3). The long tradition of collaboration in mastitis management underpinned development activities to construct SAMM as a shared intervention initiative.

> *'The SAMM (Seasonal Approach to Managing Mastitis) plan is a new approach to the control of mastitis for NZ conditions. It was based on an initiative of Dr Larry Smith, Visiting Fellow DRC, Dr Murray Woolford, DRC, and Mr Mel Eden, MAFQual, through funding of mastitis research by the Dairy Research Corporation. The*

veterinary aspects of the plan have been developed and co-ordinated by Dr Adrian Joe and the Dairy Cattle Veterinarians (NZVA). It was further developed with inputs from across the dairy industry and the National Mastitis Advisory Committee.' (Joe, 1993, p.72).



Routines

Late lactation	Drying-off	Dry	Calving	Lactation
• review clinical cases • review ICSCC • treat late season clinicals • decide dry cow antibiotic strategy	• dry off abruptly • administer dry cow antibiotic • check quarters	• test machine & correct faults • treat clinicals • enrol for ICSCC service • set up recording system	• use clean pasture • treat & record clinicals • teatspray • milk out completely • minimise suckling	• monitor machine & correct faults • treat clinicals • monitor bulk count • practice good hygiene • use good milking technique • teatspray • manage teat conditions

(Sources: Joe, 1993; LIC, 1996).

Figure 5.3: SAMM Activities and the Seasonal Change in Pathogen Populations

SAMM integrated the contributions of researchers, professionals and farmers to recommend mastitis management using monitoring methods. Dairy companies purchased the SAMM kit - an explanatory booklet and a wall chart to display in the milking shed for the recording of mastitis management activities - and provided the

kit to their suppliers as a service. Farmers could plot trends in their herd's BMSCC and take action when SCC thresholds were exceeded. The kit was provided at no cost to individual farmers. Integrating rules of mastitis management in a seasonal planning framework that relied on the use of monitoring methods was expected to cultivate a shared mission among farmers, researchers and professionals towards a continuous improvement in mastitis management.

> *'The SAMM plan represents an agreed industry wide map for mastitis control in NZ. Many different groups have provided comment and suggestions and, as far as possible, it represents a consensus view. This approach has been adopted since it provides an important industry wide focus on issues, actions and management strategies. It will create debate, it will be subject to ongoing modification as more research is carried out and field experience is considered. Much of the scientific evidence which supports the plan comes from NZ studies.... The manner in which SAMM has been extended to the industry through the dairy companies has achieved penetration to virtually every farmer in the country. This achievement illustrates the highly integrated structure of the NZ dairy industry.'* (Joe, 1993, p.75.)

The claim that '*penetration to virtually every farmer in the country*' was achieved was correct in so far as every farmer supplying a dairy factory with milk received the kit, however no surveys were performed to determine if farmers used the kits, and if so how they were used in farming.

Designers anticipated that any new technologies that enhanced mastitis management could merge with routines specified in SAMM. However, the integration of new technologies assumed a consensus among actors and organisations dealing with problems of mastitis. Who were these actors and organisations that judged when a technology contributed to the improved management of mastitis? The NMAC was dominated by professionals, with 2 farmer representatives (referred to as *users*) on the committee. The professionals and farmers in NMAC scrutinised drafts of *Mastitis Management*, and suggested modifications to the SAMM based on their field experience. The NMAC also recognised the contributions of some non-committee farmers, *'those farmers who care about mastitis - for sharing their problems and experiences, and thus contributing to the better management of mastitis in NZ, in particular those people, who by using Livestock Improvement's Somatic Cell Count service, have funded the* [programme]'. Consensus was also sought during a meeting of 40 people, prior to launching SAMM, though the organisational representation mimicked that of the NMAC - LIC, DRC, MAF, Massey and Lincoln universities, Waikato Federated Farmers dairy section, dairy companies, the veterinarian's dairy cattle society, and the milking and plumbing trades association (NZDE, Dec.1992, p.7).

Periodically the MAF and later the NMAC attempted to capture farmers' experiences with mastitis management using surveys (Laycock *et. al.* 1987; Holdaway, 1992). The combination of meetings, surveys and informal networking by NMAC to achieve national agreement among professions servicing the sector, achieved unconditional agreement on what constituted '*good practice*' at the level of national governance for each profession. Having established agreement among the professions at the national level, the NMAC used follow-up meetings with the professionals who were active in the field to outline the SAMM and reach consensus on the principles underlying recommendations to farmers (see Figure 5.4).

...We didn't go out and do many farmer meetings. Our job was to train the trainers. We did a roadshow with M-- E--, A-- J-- and M-- W--, and I chaired all those meetings. We got all the vets, all the milk quality advisors, all the farm advisors, all the milking machine people, all the Livestock Improvement people to a meeting so we had all the disciplines for the area in one room. We told them that their national bodies had locked them into this message, this is it. " Now you are hear and you are not to leave this room if you have any worries about that. So is anyone going to go from here and think they can't support it?" My job as chairman was to make it clear to them that the purpose of the meeting was to get them locked into this scheme. Some did come back and debate things and we brought those issues forward next year, but there have not been many changes or much upset. Part of my job every year is to write to every national organisation to give them the chance to say we have this plan, this is your time to suggest a change otherwise forever hold your peace. I go overboard, I write to all sorts of interesting organisations like farm training associations, about 30 different groups that don't usually have anything to say, but at least I give them a chance. And I say if you don't come back with suggested changes then by this act you are locked into it.'
(Secretary, NMAC)

This approach resulted in the governing bodies for each profession overseeing alignment with the management practice specified in SAMM. Within 2 seasons dairy companies, the NZDB and the professions were commenting that the programme was one of the most successful initiatives in the dairy sector in achieving cross organisational and professional consensus on management practice.

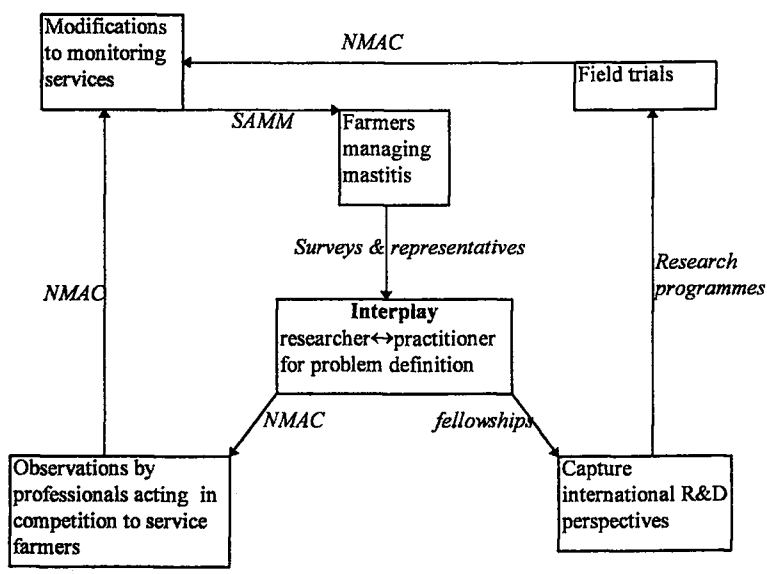


Fig. 5.4: Interaction in Mastitis Management

To influence farmers' mastitis management through interaction with professionals required communicative methods. Because the BMSCC were routinely monitored by

the dairy companies, individual farms could be targeted when thresholds were exceeded. Farmers could also purchase the ICSCC service as an adjunct to herd testing providing individual cow data as a means of early warning for mastitis. Herd testing and ICSSC service was provided by the LIC, who also provided a national consulting officer (CO) service to the dairy sector. The organisation therefore aligned ICSCC results with the fee paying option of the CO service (termed FarmWise) and offered a direct contact service in 1993 as a component of SAMM that performed a follow-up role to farmers who appeared to ignore high SCC in their raw milk.

> *A hard core of dairy farmers seem oblivious or unconcerned about mastitis and high cell count milk, according to FarmWise consultant Paul Reidy. Dairy companies' grading penalties for high cell counts in milk do not seem to be motivating these farmers, he said in a report to the recent biannual meeting of the National Mastitis Advisory Committee. Nor do the farmers seem aware of the dairy industry push through the seasonal mastitis management plan (SAMM) and the call for milk with low cell counts. They have a poor understanding of mastitis management and are generally outside the net of farm advisers and consulting officers, discussion groups, field days and seminars, Mr Reidy said. As part of the mastitis programme, Livestock Improvement Corporation's FarmWise group contacts farmers whose herd-test cell counts indicate they may be having difficulty.'* (NZDE, Dec 1993, p.21).

The targeting of unresponsive farmers was performed using herd test results for SCC centralised at Livestock Improvement. An additional communicative tool was added to SAMM in 1995 with the publication of a regular mastitis management section under the SAMM logo in the sector journal. The Monthly Mastitis Focus provided mass media extension of practice rules targeted to seasonal conditions. At critical mastitis periods like calving and drying off the written material was complemented by a *Farming With Pictures* video service - a free to farmers video disseminated monthly to every dairy farmer in NZ.

The SCC service identified the need for improved management methods, and SAMM provided the rules of practice. A third factor in changing management methods was the introduction of regulations by the dairy companies that penalised farmers for producing raw milk with BMSCC greater than 400,000/ml. (NZDE, Dec 1993, p.21). Penalty schemes varied between companies, in terms of level of penalty and frequency of monitoring BMSCC. Several companies pooled resources and established a testing laboratory to perform milk sampling while others used the facilities available from Livestock Improvement. The introduction of penalties was considered by some sector analysts to have had a significant impact on farmers who were experienced direct losses from their milk receipts (see Figure 5.5). These economic losses were more visible to farmers than the previously estimated sector losses calculated by researchers. A move to increase the frequency of testing by some companies placed more emphasis on the need for farmers to improve their mastitis management practice.

In the 1996/97 season several dairy companies increased the frequency of their raw milk sampling for individual farmers from once every 10 days to daily testing. Farmers and some veterinarians initially reacted negatively to the modification, but after three weeks under the modified scheme, the refinement was recognised as providing a fresh impetus to reducing the incidence of mastitis (Franks, 1996). Daily test results were used as management information in farmer decision making.

Demand for herd testing services with ICSCC increased and farmers were more active in scheduling the timing of services to better align with critical early and late season management decisions.

The dairy companies were emerging as significant organisations in influencing farmer decision making, through the operation of their penalty schemes, and their provision of management information as a service to farmers. Dairy companies provided SAMM kits and complemented this information with an automatic telephone service that advised farmers when their BMSCC thresholds had been exceeded. The dairy companies had daily access to changes in the BMSCC from each farm in their supplier network. Aside from the rapid feedback to farmers provided by the telephone service, the data was used to provide additional information as comparative BMSCC reports that ranked the relative performance of individual farmers in the company for the BMSCC over the season. Dairy companies established home pages on the internet and planned to offer internet users on-line access to their raw milk records. Dairy companies were therefore transforming market signals into challenges for farmers, and resourcing farmers with supplementary management information to meet these challenges. Quality management became an increasingly important aspect of farm management.

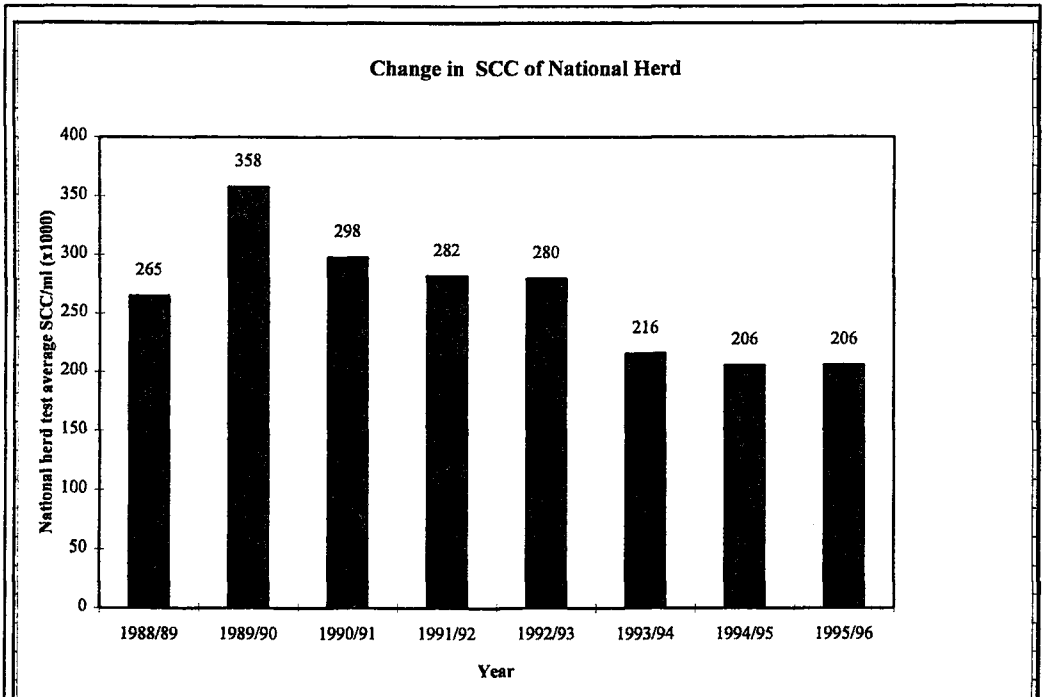
The introduction of penalties for BMSCC required farmers to manage for milk quality and milk production, and information resources were provided by various organisations to assist farmers to meet this dual challenge. With the provision of information arose an issue of intellectual property rights. SAMM kits were not branded in the 1995/96 season to encourage their use by dairy companies as a service to their farmer suppliers. The following season kits were branded as LIC publications, in an effort to identify SAMM as an NZDB initiative complementary to the activities of dairy companies who were explicitly branding their information services to their suppliers. This branding of information represented a demarcation of professional domains and organisational roles in the sector. Collective action was fostered among the professions by keeping SAMM neutral in terms of property rights, each organisation had an ability to exert some form of ownership over the programme in the context of their professional domain. The negotiation of professional domains was therefore an ongoing activity in sector level mastitis management.

Consulting officers running dairy discussion groups[3] noted an increasing interest by farmers in debating the management of mastitis. During these debates farmers demonstrated a comprehensive knowledge of mastitis and the use of well developed routines for managing their herds according to the new rules specified under the recent penalty schemes by dairy companies.

> *'Some farmers intuitively operate a breakeven analysis on individual cows, whereby a high producing high SCC cow is retained, provided the bulk milk count remains below the penalty. A decision rule to optimise profit requires information about individual cow SCC status and the level of total milk yield dilution.'* (Paine and McCall, 1996).

[3] A national network of discussion groups for NZ dairy farmers provided by the NZDB through the Livestock Improvement Advisory service

How did these development efforts towards the emergence of common practice affect the quality of NZ raw milk in recent years? National herd test data indicated a significant drop in SCC in the year following the introduction of SAMM and milk penalty schemes (see Figure 5.5). Early and late season peaks in SCC remained high, being inversely correlated to milk volumes (Lacy-Hulbert & Woolford, 1996). SAMM seasonal orientation provided a convenient instrument for subsequent research towards analyses of early and late season management systems, the management of mastitis in heifers, and new approaches to the use of DCT (Williamson, *et.al.*, 1993; Pankey & Pankey, 1994; Lacy-Hulbert *et.al.*, 1995; Lacy-Hulbert & Woolford, 1996). Data trends over the past three seasons provide a limited appreciation of the achievements of change in mastitis management practice. Longer term implications may arise from the increased use of DCT, at a time when increasing emphasis is placed on reducing the use of antibiotic in animal health applications (NZDE Dec1993, p.21; NZDE, Oct1996, p.37; Salmon, 1996). Researchers and field professionals responded to these concerns by shifting development efforts from the reduction SCC to the minimisation of risks associated with antibiotic residues contaminating milk through errors in application procedures (Woolford, 1996).



(Sources: LIC, 1996).

Figure 5. 5: Trends in National SCC following the introduction of SAMM

6.2 Critical Issues

The way researchers approached the initial SAMM design - based around the use of teat end protective mechanisms - simplified the task of managing mastitis and enabled the alignment of activities like planning using the SAMM kit, and monitoring using the ICSCC service, or the use of information services from dairy companies. As professionals acted on the initial developments from research, a consensus emerged in the sector as to what ought to be done in terms of managing mastitis. This normative position was embodied in media like press releases, videos and discussion groups that were resourced from levies charged on the monitoring services that farmers purchased.

Whereas the building of SAMM and the use of monitoring data built a shared consensus on what ought to be done among actors in the sector, it was the introduction of penalties that encouraged farmers to change their methods for managing mastitis. Farming became a game of production and quality management, and change emerged when economic incentives (penalties) were connected with an ability to perform using the general rules of SAMM and monitoring. Dairy companies used price mechanisms to signal their requirements to farmers, but depended on connections with NMAC to equip their farmers when changes in methods of management were required.

The NMAC provided an interface for the specification of a common management practice, using SAMM to extend the rules of management to the sector. This interface was dominated by professionals who then disseminated their consensus about the rules of mastitis management to farmers using SAMM. Consulting officer experience suggested farmers preferred to use interactive communicative tools like discussion groups that provided an opportunity to modify aspects of their farming using debates about their rules of management. For professionals to access the rules that farmers used in their management, active interaction in field settings was often necessary, though mail or telephone surveying were also periodically used. Upon the introduction of penalties the locus of influence on farm decision-making moved from NMAC to the dairy companies. The dominant organisations influencing mastitis management were the dairy companies who possessed a combined capacity to provide information resources through NMAC, and introduce economic drivers through pricing mechanisms to motivate change. Following the recent activities of dairy companies, NMAC assumed a sector responsibility to endorse programmes and tools offered to farmers by diverse professions that contributed to mastitis management.

The way the NMAC worked with the national organisations that governed the professions was also informative in terms of harmony in the theatre of innovation. The professionals in NMAC were actively working on mastitis issues, they were not necessarily politically active in their respective professions, but they were sufficiently connected to monitor reactions among their colleagues and encourage those in governing roles to support NMAC initiatives. The NMAC therefore used a two step process: first gaining the support of leadership; then later using this support to legitimate requests for co-ordinated activities from individual field professionals. This procedure enabled NMAC to withdraw from issues of competence within the

professions, leaving issues of judgement and governance as an internal task for the profession.

> *If that got formalised* [the mediating practice] *and you weren't part of an organisation the way I am, which has constantly got new challenges coming at it, you could get bogged down. There is a real potential to be professional in this area. I try to keep in touch with Livestock Improvement. At one stage I was getting pushed out into a little role in the information technology area. I was losing my daily understanding of the problems and contacts in the field. So you have to be in the real world but loose enough to follow it up issues for development.* [Secretary, NMAC]

If monitoring identified the need for change in managing mastitis, SAMM specified how to change, and the penalties specified the consequences of management. The farmers used opportunities to change their management methods when they deemed it necessary, by demanding more services like more ICSCC and specifying modifications to these services to meet their practical needs. Dairy companies introduced new information technologies in an effort to improve their assistance to farmers. New technology also reduced the costs of monitoring, like BMSCC enabling more frequent testing and consequently more useful management information. The simultaneous development of services by several organisations prompted regular (re)negotiation of professional domains, though the NMAC remained an overarching arbiter of what constituted good practice when managing mastitis. A new generation of problems, like the use of antibiotics under more stringent SCC regulation, had associated higher risks to the sector and were expected to stimulate further changes in managing mastitis.

6.3 Emergent Learning

SAMM was a formal planning response, made initially by researchers but later to encompass professionals, that was to be a means of aligning technologies. SAMM was not a practice, as a farmer does not do SAMM, rather farmers manage mastitis by following the rules outlined in SAMM. SAMM therefore embodied the rules of the game for sector-wide mastitis management. The influence of research was to specify how to direct activities to resolve mastitis problems. Selecting the teat mechanism as the basis for preventative and curative action simplified the alignment of activities. The SAMM kit, when combined with the SCC service and a dairy company's information services, provided farmers with an opportunity to organise their activities consistent with the rules of mastitis management. The SAMM therefore grounded the outcomes, from the interplay of practices operating in research, farming and the professions, as rules for mastitis management. These interplays served to reduce errors performed by each of the practice, and helped to clarify their respective domains of action.

Change in the sector management of mastitis required some combination of regulatory powers and professional consensus. Formal and informal arrangements were active in combining regulation and consensus to adapt to signals for change that came from government policy and markets. Dairy companies made formal arrangements to penalise farmers. These arrangements were also dependent on goodwill existing between the processing company and the farmer suppliers. By providing information

services as a countervailing position to the penalty schemes, the companies attempted to create a balanced position on managing mastitis and reducing SCC in raw milk.

Consensus among the professions emerged as some professionals worked to create a collective position on managing mastitis. Their activities engendered a sense of ownership using the NMAC as an interface for an interplay of practices. The activities performed in the NMAC, and it substantive concerns were at a level (sector wide) that did not interfere with activities and substantive concerns of each profession. To convey the normative position on managing mastitis that emerged out of the interplay of practices, the NMAC used its resident professionals to build access to each profession's governing body, thereby gaining endorsement of mastitis management norms, and subsequently influencing the respective fieldbased professionals.

Resourcing sector-wide initiatives appears to have implications for programme managers at three levels: at the level of farm production the farmers were willing to pay for services that helped link their activities with beneficial outcomes like reduced SCC in their raw milk; at the level of building consensus among the professions, the professionals contributed on the basis of work in kind; at the level of co-ordination among practices in the sector, the NMAC was supported by the NZDB who was ultimately accountable for the quality of raw milk offered to consumers.

7.0 Conclusions

This case study investigates the question, how is a sector-wide intervention worked out by the actors and organisations operating under free market policies? The question is relevant to the issue of achieving a sector-wide capacity to perform in harmony with respect to the problems or challenges that confront that sector as a whole. In terms of managing mastitis it was the interplays among the practices of farming, milk processing, and technical support like research and consultancy that worked towards an emergence of sector mastitis management as a broker practice. However this creates the need to further clarify the distinction between the activities of actors, and a practice - more specifically, when does a practice emerge? The discussion in this conclusion responds to the above question and investigates the significance of the response for the management of technology in the dairy sector.

Dairy cows, and consequently farm and sector performance, were suffering from mastitis infections before the introduction of the 5 Point Plan in NZ. Farmers were taking action using the advice and materials provided by veterinarians, as part of normal farming. The activities of farmers, veterinarians and others were organised to construct methods of management. These methods used hardware and were guided by rules. Therefore all the aspects of a practice were already present in the dairy sector prior to the introduction of the 5 Point Plan. However the programme that introduced the 5 Point Plan provided an interface for actors to combine their work and perform jointly on mastitis management. Joint performances on the 5 Point Plan were complemented by other joint performances like the development of monitoring methods and the reorganisation and modification of rules in the 5 Point Plan into a

seasonal planning method, the SAMM. The co-ordination of these joint performances was achieved through an interface operating at a second level - the NMAC.

The NMAC as a formal committee provided an organisational arrangement, or mediating interface, for practices to interplay around problems of mastitis management. However it was the **activities** of the NMAC that fostered interplay among practices and brought about a broker practice - a sector-wide mastitis management. A mediating practice therefore emerged out of the formation of the NMAC interface. This mediating practice could be recognised in terms of the strategies employed to harmonise mastitis management in the sector (see Figure 5.6). For example, one strategy was to enlist onto the committee those professionals who were considered exemplary actors in relation to mastitis. The NMAC emphasis was on enlisting the actor, or that aspect of the actor[4] that performed in a practice, rather than the professional. For example a veterinarian may be judged a good veterinarian by colleagues yet perform as a mediocre actor in a number of practices. What the NMAC did, perhaps implicitly, was to bring about a distinction in levels of practice. At one level, farming corresponded to processing and marketing practices. At another level, a practice of mastitis management corresponded to a practice of reproduction management. These management practices were performed on farms, but other actors were involved with the farmer in the practice. A mediating performance by the NMAC was therefore to foster what it judged appropriate interplays of practices on farms towards the emergence of mastitis management. It did this by embodying the rules of mastitis management in SAMM, and combining these with monitoring activities as rules of adaptive management.

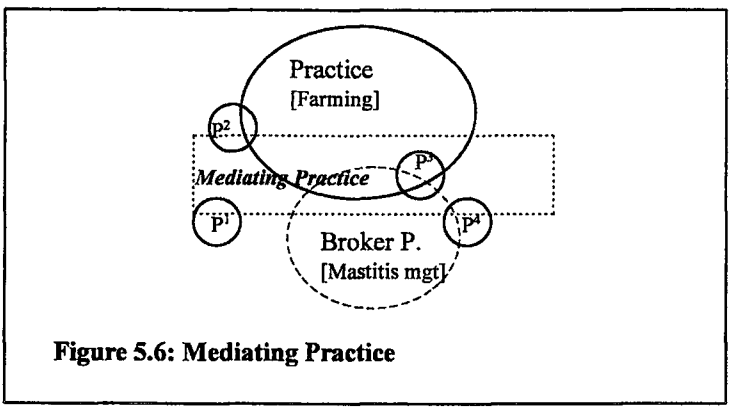


Figure 5.6: Mediating Practice

The enlisting of professionals, along with farmers and researchers, depended on the existence of a problem that was of sufficient concern to attract participation. The problem defined the scope of the interface, which tended to expand with the emergence of new mastitis management methods. This expanding scope enabled the NMAC to remain impartial, co-ordinating overarching rules of management while the professions and others negotiated their domains of action. Changing organisational relations influenced how NMAC performed mediation. The dairy companies were

[4] commonly referred to as the practitioner

also mediating mastitis management through a combination of economic incentive and information support to farmers. In as much as the dairy companies were enlisted in the NMAC, the consistency between their policies and the NMAC overarching rules of mastitis management were worked through interplays of practices into formal regulations by organisations. At times the enlisting of those outside the NMAC provided sufficient independence to resolve disputes at the NMAC interface.

The case of mastitis management indicated that the emergence of a broker practice - a sector-wide management of mastitis - involved a constant searching for solutions to an intractable problem. The resourcing of this searching and subsequent problem solving activities occurred at several levels. At the farm level the rules for resource allocation were fee for service based, whereas sector level co-ordinations used NZDB resources. With NZDB support the NMAC could continue irrespective of changes in farm level perceptions of the significance of mastitis. This raises the issue, ought a mediating interface continue in existence when the problem appears resolved? Evidence of the reduced SCC in raw milk from the national herd may suggest to some that the initial objective of the NMAC to reduce SCC to 150,000/ml will be achieved as a matter of routine. However, the NMAC represented an ongoing investment in an interface that if dismantled for want of a problem domain would prove expensive, if not impossible to reinstate. It is beyond the scope of this case to analyse the transaction costs for different scenarios relating to the fate of a mediating interface, suffice to say that in such analyses some account must be made of the relative effectiveness of the interface for the interplay of practices.

To conclude, actors perform in an emerging practice which is co-ordinated at a second level - a mediating practice that fosters the interplays. A mediating practice operates at the interface of interplaying practices working on a shared problem. The strategies of a mediating practice will depend on the types of problems confronting the interplaying practices. The nature of problems around which practices interplay has differed between a tightly specified synchronisation problem in the CIDR case study, and a multi-faceted sector wide reduction of SCC in the SAMM case study. A third type of problem is confronted when a sector has a high level of awareness of an obscure problem domain, where the rules of the game are so rudimentary they are in a state of constant flux. Such is the case with issues of sustainable resource management in relation to farming. The following case study will explore how an analysis of practice can contribute to the problem of alignment between farm production and resource management goals.

Chapter Six

Expedient Resource Management: A case study of the sustainability study group programme

'Local dairy farmers are leading a research project that aims to provide farmers with information that will encourage sound economic on-farm decisions ... essentially these decisions are those that will not only impact favourably on the financial aspects but are decisions that will impact favourably on our farming resources.' (North Waikato Tatler, 15 May, 1996)

1.0 Introduction

This third and final case study differs from previous analyses in terms of the complexity of the problem domain that challenged the actors. The Sustainability Study Group Programme (SSGP) was a unique initiative in the NZ dairy sector, being a joint venture between the national farmers organisation (Federated Farmers), AgResearch and the regional resource management authority (Environment Waikato). This joint venture was formed to *'build sustainable farm practices'* that aligned farm production goals with resource management goals. The programme provided an exceptional opportunity to observe technology development activities performed by a collective of actors operating in the programme. These actors had multiple interests, problems were initially poorly defined, and an evolutionary programme design was adopted. Finally, difficulties in gaining access to critical interactive activities operating among the members in the group were minimal, enabling the use of an action research strategy. The SSGP therefore provided an opportunity to investigate the question of how harmony in the theatre of innovation is worked out when practices interplay around complex and obscure problems, and how actors come to share substantive concerns.

The SSGP spanned the sheep, beef, and dairy sectors. This case study is specifically concerned with developments in the dairy sector, to retain contextual continuity and align with previous case studies. The dairy group involved eight farmers and three professionals[1] and three researchers.

This chapter outlines the conditions and formative work by a few actors to prepare the way for a programme that involved farmers and others working together in the development of farming methods that improved the alignment between resource management and production goals. Analyses explore the building of the programme and the emergence of collective action towards an integrity of actors who perform in interplaying practices.

2.0 Formative Work on Resource Management and Farm Production

2.1 Significant Events

The Resource Management Act requires Regional Councils to maintain environmental standards in their catchments (RMA, 1991). Typically Councils employ some combination of coercive and educational interventions to discharge their responsibility. Difficulties confront landuse stakeholders when they lack agreement on environmental standards. In 1993 the Federated Farmers wanted to take pre-emptive action to avoid the imposition of regulations on farming by Regional Councils. Around this time, funding organisations were encouraging researchers to move programmes with a production emphasis towards the study of methods for sustainable landuse. When J--[2] and L--[3] recognised a shared need to develop a knowledge base for guiding farming and the management of natural resources, joint effort went towards the design of a study group programme.

J-- and L-- searched for other[4] interested parties to resource and service their needs. Federated Farmers provided a farmer network that largely eliminated problems of access to key informants. AgResearch provided experience with funding applications and information resources. Neither organisation had the financial resources, nor extension networks to implement a programme of change toward improving farm methods with respect to resource management issues. Approaches were made to FRST, MfE and MAF Policy for financial support. Initial proposals rated well in terms of relevancy, but poorly in terms of research design criteria. As the pair worked to prepare and (re)submit proposals they developed a shared viewed of land management. J-- developed more confidence in L-- and her insights gained from a recent study tour in Australia. Conversely, L-- enlarged her appreciation of the issues confronting farmers grappling with the RMA and the threat of non-tariff restrictions on their farming. The successful proposal was designed in partnership with the extension research team in AgResearch. The proposal involved a nation-wide series of workshops with farmers and policy-makers to identify what concepts they linked

[1] A distinction is made between farmers and professionals who provide services to farmers. The term does not imply farmers are *unprofessional* in the context of relative occupational status.
[2] the Chairman of Federated Farmers Dairy Division
[3] a Science Programme Leader
[4] be they individuals, groups or organisations.

with sustainable farming. These workshops produced a simple hierarchical arrangement of concepts that facilitated subsequent communication among farmers and policy makers (see Figure 6.1).

A workshop conducted in late 1993 with farmers in the Huntly district required farmers to arrange concepts they associated with the term sustainable farming into an hierarchical order using sticky paper. The resulting arrangement ordered concepts as outlined below. Farmers listed 7 conceptual categories at the first sub level below Sustainable Farming, and ordered to 3 sub-levels below the first level prompt.

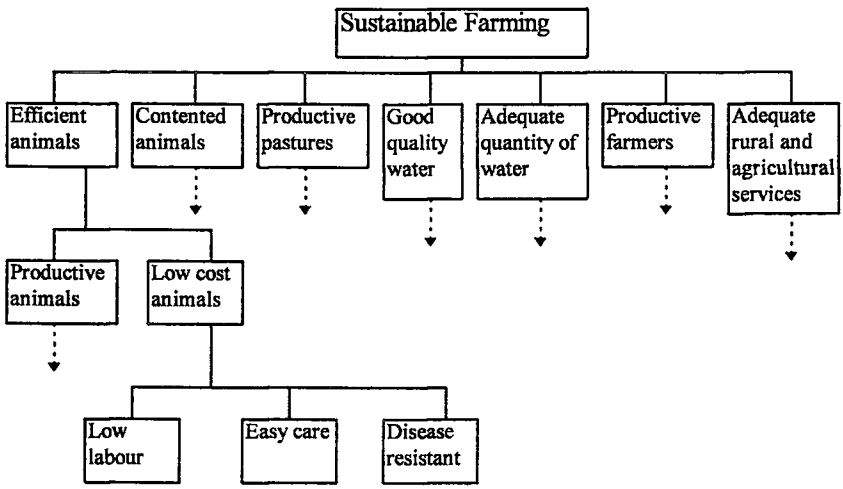


Figure 6.1: Hierarchy of Concepts Farmers Associate with Sustainable Farming

(Source: Parminter *et.al.* 1994.)

An interdependence evolved among J-- and L-- as they grew in confidence about the possibilities for an interactive programme with farmers. This interdependence grew as the pair provided mutual support in response to repetitive rejections of initial proposals by the funding organisations. However, the general problem of aligning resource management and farm production was of sufficient concern to the administrators in the funding organisations that they assisted with the work of converting unsuccessful proposals into an operative programme. This joint work activity generated a shared familiarity with the issues and complexity of resource management and farming.

As programme leaders, J-- and L-- were striving to place the NZ dairy farm system in a global context while simultaneously focusing on the actions that individual farmers perform in their routine management. Their hope was to anticipate non-tariff restrictions that might be imposed on NZ dairy farming, while simultaneously working to clarify, *'How do farmers develop and use information as they perform*

their work?'. Success with the funding organisations enabled the preparation of 'Inventories' on three farms destined for intensive scrutiny by a study group. The content of the inventories was sourced directly from extant farm records. A second initiative using farmer based information saw the preparation of *Farm Practice*[5] *Guidelines*. Researchers interviewed farmers to determine their current methods that they related to resource management. Professional journalists wrote guidelines for landusers based on the information provided by the farmers. The resulting manuals were distributed by Federated Farmers to their members and allied agencies interested in land management. The Federation maintains an active network among manual holders, regularly updating the contents of manuals consistent with new outcomes from work in the programme. Workshop reports, inventories and manuals of practice guidelines were the products of a programme designed by professionals who were gearing themselves to work interactively with farmers. It was the study group that was to provide the interface for interplaying practices.

2.2 Critical Issues

The making and enforcing of regulation by central government created uncertainty in the theatre of innovation. The rules of land management may have required change but no one actor had worked through the consequences in terms of changes in dairy farm management. The new legislation would feedback to farmers any errors in their management methods, in the form of penalties imposed by regional government who performed as custodians of the nation's national resources. This uncertainty also offered an opportunity for farmers to pre-empt the possibilities of non-tariff trade barriers restricting their ability to farm in future generations. Coinciding with the changes affecting land management were changes in the rules guiding funding for agricultural research which placed more emphasis on research towards sustainable farming. The problem that farmers faced in aligning goals of production and resource management enabled research and farm organisation needs to be aligned in a potential win:win situation. Farmers gained access to research resources (tools, techniques and networks) to reduce uncertainty associated with changing their farming to accommodate resource management needs. Researchers gained access to working partners struggling with concrete resource management problems. The organisations complemented one another in terms of shared networks and resources to build a development programme. Both organisations also shared dependency on a third party - the funding organisations.

Work on the proposal revealed problems at a second level. The problem of constructing a proposal was a problem of design: more specifically, what type of work is required to resolve the common problem? Without clarification of what type of performances were required, the proposals lacked credibility with funders, resources were withheld and work was stalled. An impasse situation was resolved when administrators in the funding organisations connected their needs with the proposal development requirements and thereby assisted with work on the proposal. A positive outcome of the failures with initial proposals was the growing interdependence among the programme leaders as they were forced to reflect on the work they proposed to

[5] Practice was used in the programme to refer to the practical activities that farmers perform.

perform, and justify to others why this work was necessary. The discipline of proposal writing therefore had each leader confront and appreciate the world of the other.

A successful proposal provided access to funds that were expended on workshops, inventories and the publication of farming guideline manuals. The hierarchies and *practice* guidelines were generalisations and representations of the landusers' world. These activities and documents provided a standardised interface for the actors in the programme to access the issues and needs confronting diverse landusers. These documents did not necessarily inform landusers like dairy farmers, because they were representing the information that farmers supplied back to the farmer. An incestuous feedback situation would have emerged if opportunity was not provided for the farmers to actively develop new methods of farming with other actors who were not farmers. The study group provided the dynamic interface that farmers required to work on problems of resource management in the context of their routine farming.

2.3 Emergent Learning

Needs can be defined in terms of a general common problem like resource management and farm production, but a second level of need definition is also necessary when joint work activities are envisaged by the actors. It is at the level of design for programmes that the definition of needs is most difficult, yet most necessary. Difficult, because no actor had blazed a trail that developed successful farming methods following the new rules set out by the guardians of the RMA - indeed the RMA guardians were also muddling through the development of their rules for administration. Necessary, because the funds were allocated to the programme development outcomes that could demonstrate a connection with the problem.

Clarity of purpose extends to defining the types of outcomes generated by the programme. Documents, and working together in workshops, are not so much the contribution from the programme to farmers, rather constructing these documents provided the farmers with an interactive means of accessing the resources of others who may contribute to resolving their problem.

3.0 Building a Programme

3.1 Significant Events

J-- co-ordinated the formation of the study groups using a combination of farmer and organisational networks. Selected farmers were invited to join a 'Sustainability Study Group' to participate in the joint investigation and incorporation of resource management goals into their routine farming. Farmers were selected on the basis of their known interest in resource management, community development and participation in discussion groups. J--'s political profile assisted in attracting support from LIC[6], the organisation responsible for extension services to the dairy sector. L-- attracted the involvement of the local regional council using previous professional and

[6] Livestock Improvement Corporation Ltd.

social networks with council staff. The role of the Regional Council was to advocate improved management of natural resources in dairy farming. Partnerships were also formed with groups within AgResearch, like AgSystems and Soil Research. Researchers from these groups were to provide specialised technical input as and when farmers requested it. In summary, each organisation occupied specialised roles in the group:

- Facilitator: Consulting Officers [LIC]
- Systems specialist: scientist [AgResearch]
- Natural Resource specialist: field officer [Regional Council]
- Programme management: scientist [AgResearch]

The programme leaders considered these roles constituted a structure that would support farmers to express their often implicit reasons for doing what they did in their routine farming, and thereby enable the generalisation of this reasoning into a systematically organised body of information for use by interested others. Professional input to the programme was remunerated at market rates, and farmers participated voluntarily without remuneration. The programme leaders used several planning criteria, viz.: funding must be appropriately aligned with the task to create an environment with a high chance of fostering collective learning; members of the programme were respectful of each others' experiences and came to meetings with an intent to develop and use hardware, methods and ideas collectively; any expenditure on monitoring and reporting would require unanimous demand for the information and have a high chance of benefiting the programme as a whole.

The dairy sustainability study group had its first meeting in April 1995, with many members meeting one another for the first time. Interdependent working relations did not exist among members prior to the meeting, indeed they possessed a limited understanding of the purpose of the programme. The members shared uncertainty about how the group would evolve. In some cases professionals present in the group were guarded towards the presence of other professions.

The sustainability study group was an intervention planned and co-ordinated by the programme leaders with initial design work and the preparation of proposals not involving the farmers in the group. Farmers did have a joint role in the planning and management of the groups upon their inception, but it was the researcher and professionals using their respective sector networks who scoped for resources and contributions to group goals.

The farm inventories were designed and written by researchers. These inventories were used by the facilitator in the initial meetings, but by the third meeting the inventories were largely irrelevant to group activities. A general consensus emerged in the group, following the use of the inventories, to build an information system that all members would share. Several efforts over a six month period failed to frame the scope or assemble the components of a shared information system that farmers could used in their routine farming. This failure was not due to a research imposed ideal. Farmers were to the fore in requests for the development of information and decision support tools. Yet every attempt by researchers to provide practical information tools failed to develop beyond general conceptual ideals with farmers. These efforts to

build information tools in the form of monitoring systems and software support did however provide the group with a situation requiring joint effort. Members became familiar with the needs, aspirations and constraints of others in the group. Farmers started to weigh their stock regularly, and used the meetings as a forum for comparative analyses. As weights were recorded and discussed the group began relating various

The design implies that current dairy farm practice cannot be shown to equate with the expectations of resource management advocates. Through an iterative group process using models, monitoring and group learning methods needs are defined, actions taken and evaluations performed to generate tools and methods that assist the alignment of resource management and production goals.

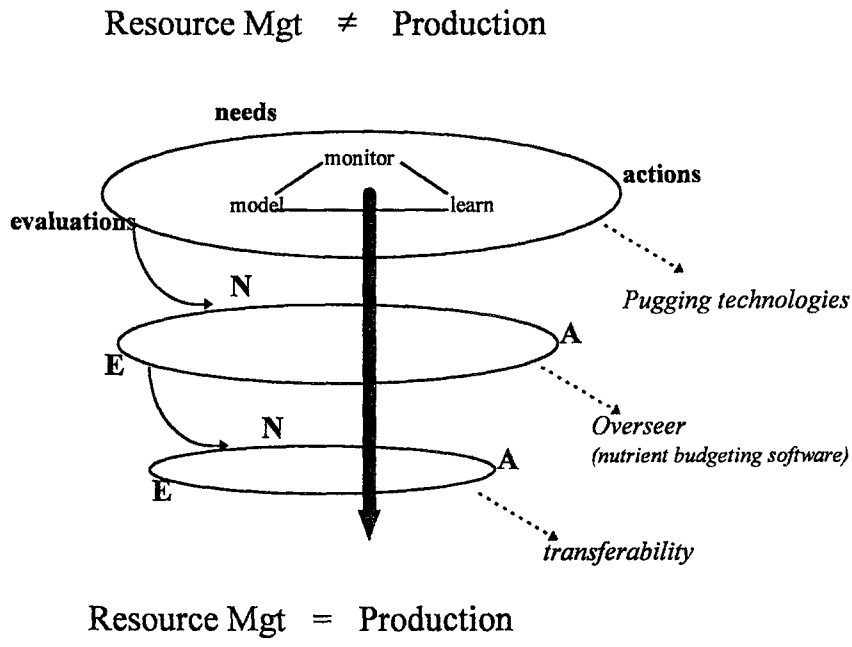


Figure 6.2: Schema of Programme Design for Dairy Sustainability Study Group

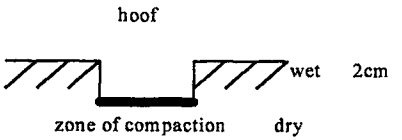
aspects of the farm system and seasonal conditions to the resultant weights. Stock weighing encouraged farmers to attend to stock individually, providing preferential treatment for different classes of stock. Farmers considered the weighing results were a useful integrating indicator of their farm system performance over time. Several debates emerged about the way weights were collected and interpreted. For example, should weighing be performed before or after feeding? Yet herein lay a conflict with Regional Council and resource management professionals. They considered the group was over indulging in production issues and presenting a mere facade of concern for

resource management issues. Programme leaders became hard pushed to maintain the interest of the resource management advocates in the group.

Box 6.1 Debating the Management of Pugging

In May 1995 the farmers requested a workshop on pugging, starting with a soil physicist specialising in the analysis of pasture pugging. A section from his opening presentation is followed by a except from subsequent group discussion using points conveyed in the talk.

'*What is the soil? It breathes, it needs nutrients, and it grows, it is unique, and it is very fragile and may not recover immediately from insults. So soil can be thought of as a living thing.... What is observed in the topsoil: microbial life, air spaces, fragments of rock and organic matter. The soil is more sponge like than solid. Soil is completely different to rock. It is as different as bread is to grains of wheat. Compaction is the physical compression of the soil, and it occurs when it is raining and the cows walk over the soil.*



The hooves press the soft soil down onto the dry hard soil, the wet soil is compressed between the hoof and the dry soil. Over time the soil reaches a critical point, called the liquid limit which designates how much moisture the farm can take. You notice some soils are more prone to pugging than others - this the difference between the different liquid limits of the soil.... The soil as a living thing is affected by the pugging. It needs to breath and the pugging has reduced the air spaces making it hard to breath. The main rooting zone is about 20cm deep, where 90% of the soil activity is occurring. The is where most of the nutrient transformation is occurring. It is also one of the most fragile environments. Compaction alters the drainage characteristics, so the paddock becomes even more susceptible to pugging ...'

Following a brief presentation on pugging, the farmers followed up on the significance of soil moisture, specifically querying the implications for their farm practice:
Consultant: *'they* [Hauraki Farmers] *definitely seem to think it [rolling pastures] is a good thing to do. There is an optimum time to do it in, you have to do it at the right soil moisture content?'*
Scientist: *'yes, moisture content is critical.'*
Consultant: *'so, is it not an acceptable practice then?'*
Scientist: *'well I'm not a practicing farmer, but from a soil physics point of view I wouldn't recommend it.'*
Farmer: *'what about in the summer, wouldn't a soil with high and low areas dry out more?'*
Scientist: *'there is something in that, but maybe with time the grazing of animals will knock the tops off and smooth it anyway'*
Farmer: *'well they do, but you try to speed that up by rolling. The other thing is farmers like to see the paddock look nice and smooth, and you don't want to be bumped about on the motorbike'*

Autumn 1995 was remembered as an indian summer in NZ. A late abundance of feed relieved farmer concerns about cow condition[7] going into winter. This relief was short-lived as an exceptionally wet winter dragged on into spring. Farmers feared long term damage to pastures as cows walked over waterlogged soil (pugging). Study group farmers had elected to study pasture pugging in May, just prior to the wet winter. They enlisted a scientist to deliver a workshop spanning the basics of soil physical damage from pugging, and to report on local experimental work that made estimates of economic losses due to the pugging of pastures. This workshop was significant in that it contributed to bridging resource management and farm production concerns in the group. The researchers were skilled communicators. They approached their subject with enthusiasm and humility before the farmers. The workshop opened with instructional learning experiences characteristic of earlier group activities. Yet the possibility of an acute farming need, combined with a professional presentation, stimulated collective learning activities. Farmers were questioning researchers who were frank about the limits of their understanding of soil:pasture responses to pugging. The ensuing debates among members of the group identified several monitoring tasks for farmers to cope with during a wet winter (see Box 6. 1).

Each farmer developed their pugging management methods and discussed the outcome of their approach after calving in spring. One farmer exerted himself more than others in the group because of the high clay fraction in his soil and his interest in the pugging issue. His farm hosted the pugging workshop. He visually monitored his paddocks and regularly moved stock off when conditions were judged too waterlogged. By spring his stock had sore feet from standing on hard surfaces, but pasture damage was minimal. Stock problems with sore feet proved a temporary issue as cows were moved back onto the pasture.

Follow-up discussions that explored farmers' experiences with pugging during the wet winter convinced members they had a message to extend to the dairy sector. Researchers and farmers worked together in the preparation of pugging guidelines that were included in the sustainable farm practice manual. A second type of follow-up was also used, whereby the researchers and professionals met after each group meeting to evaluate the day and provide feedback on their performance in the group. This feedback was primarily concerned with the way individual researchers and professionals performed in terms of content and interactive communication. These evaluative meetings were used to plan the next meeting and set personal plans for improving interaction with farmers.

> *'The whole thing is like an invisible wheel behind a wheel and the farmers should be getting on with building content and not bother with what is happening in terms of process, so that at the end of 3 years they can carry on, and the programme people can move on and develop other things so that the programme could develop wider. In the end farmers don't care about process, they are concerned about content, they don't*

[7] The overall health and form of the cow, in NZ a cow condition scoring system is used, whereby cows are scored and heuristics used to manage according to the season - for example, farmers regularly talked of the need to have cows at a condition score of five going into winter, meaning the breeding cow need sufficient body reserves to grow the calf on poorer quality winter feed, and rapidly recover body condition to convert grass into milk using the higher quality feed available in spring and early summer.

care how they got there so long as they feel comfortable.' (Programme Leader, July 1995).

3.2 Critical Issues

The connectedness of the programme leaders in their respective networks enabled an enlisting of important others to represent diverse positions on resource management and production goals in the programme. The group was established using routine group development rules, with the definition of roles and use of criteria to perform tasks and allocate resources as a group. However, the goal of helping farmers to reflect on their actions and build a generalisable information resource was inconsistent with the operation of the group. If farmers had to perform their routines to reflect and thereby reason, then reasoning came out of the doing. How then would this generalised information transfer to others, except that the others also go through a reasoning by doing experience?

The events in the seasonal production cycle were connected with the emergence of group activities and programme development. With favourable production conditions the group worked to refine their routines using monitoring methods like the weighing of stock. The dominance of farmers, supported by a facilitator with an orientation towards production systems, meant the group as a whole worked on comparatively familiar production tasks, rather than undertake the uncertain territory of resource management. The dominance of production as the topic of development exasperated the resource management advocates, who were enlisted by the programme leaders and had not initially sought to be actively involved in group activities. Resource management advocates found that few of the concerns raised by the production oriented members were relevant to their view of resource management and they were preparing to discontinue their involvement in the programme. The identity of the *group as a whole* did not include the resource management advocates. The onset of winter with corresponding pasture management problems like pugging achieved what arguments by resource management advocates could not - the development of new methods to monitor and manage stock:pasture:soil relations with a view to resource management and farm performance. The group had a capacity to access materials and methods that were worked through collectively to build farm level responses to pugging problems. A new group identity emerged as the group wrote pugging guidelines using the information they had accumulated while managing through the wet winter. Universal rules for pugging management were not proposed, as each farmer responded to the idiosyncrasies of their own farm, and then compared methods and pasture responses with the soil type and topographical features of each farm.

Researchers and professionals took care not to dominate debates, rather they specified the gaps in the research work, and encouraged debate with and among the farmers. The development of improved communication methods was recognised by the researchers and professionals as a critical need for the emergence of the group.

3.3 Emergent Learning

In organisational power arrangements the programme leaders needed to operate at a level that gained access to key actors and resources. Furthermore, these leaders needed effective networking routines to benefit from their organisational status and enlist the support necessary for the development of the programme.

The routines for managing the group were adequate for group learning needs. However, the challenge for the programme was the transfer of learning - perhaps the medium was the message (Khatoonabadi and Bawden, 1993). It was when members actively worked on problems that methods developed and resource management *found a place* in the world of the farmer. This is not to imply resource management was never a part of farming - rather it moved from implicitly performing routines for maintaining soil fertility to explicit reflexive activities that developed new ways of doing, the development of methods for maintaining soil fertility.

There are risks associated with programmes that leave the development of work content in study groups to emerge within the group - a muddling through design for the discovery of work. These risks are that the scope of work activities may remain within the comfort zone of the majority of members, while neglecting the performance of some activities that are critical to attaining the purpose of the programme. However these risks are necessary if the programme is to muddle through towards the alignment of resource management and production goals. Programme leaders cannot hope to anticipate common needs, such as those that emerged as the wet winter took effect on the activities of the group. Part of the enthusiasm in the group towards the collective construction of pugging management methods emerged from the very spontaneity of the wet winter events. A problem like the pasture effects from a wet season fostered cohesion in the group as part of an overriding need to take action on resource management in farming. Group cohesion was a consequence of the joint activities, not a precursor to performing joint activity. Furthermore, members required a problem of sufficient consequence to create uncertainty and a need for a change in farming methods. The researchers and professionals had another sort of need - to develop communicative methods that interactively built the content of the programme. An interactive communication can frustrate farmers and others if an actor can provide relevant content to the group but withholds information based on the perceived rules of an interactive process. By using routine evaluations that provided feedback and workplanning activities, researchers and professionals discovered ways of enthusiastically using information on pugging towards building management methods for reducing uncertainty about pasture damage and recovery.

4.0 Collective Action

4.1 Significant Events

The group experienced an hiatus following the writing of the guidelines. Several resource management issues were alluded to by the scientists in the group but these were of limited interest to farmers. Water quality issues were a central concern to the Regional Council members, but farmers considered water quality of little significance

to their farm management. Water quality appeared to researchers as a logical extension of the pugging problem, the latter being a type of non-point source water pollution. A workshop on water quality was organised to build on the programme success with the pugging work. Farmers demonstrated a quizzical interest in the content of the day, but no substantive activities were prompted. Programme leaders realised the need for a refined sense of purpose for the group or the programme would flounder.

Table 6.1 Survey Results from Self Assessment of Information Priorities

In October 1995 the group decided to list their information requirements and determine their group priorities. They identified the categories of information they collect and use in farming (left hand column); and scored themselves according to the importance of the records (1 = very important, 5 = unimportant); and whether or not they currently collected records for that category. Non-farming members in the group differed from farmers on a number of specific categories. Non-farming members scored more categories as important record keeping topics compared with farmers.

Recording Category	Farmer rating	Range	% Farmers Recording	Non-farm Rating
Soil testing	1.3	1 - 2	90	1.2
Mastitis: occurrence and treatment	1.5	1- 3	60	1.6
Pasture cover (DM/ha) - farm average	1.6	1- 3	40	1.2
Stock numbers - replacements	1.6	1- 3	100	1.0
Milk Production Records	1.6	1- 3	100	1.2
Calving - date and spread	1.8	1- 3	100	1.2
Fertiliser - each paddock rate (kg/ha)	1.8	1- 3	75	1.4
Fertiliser - totals	1.9	1- 3	90	1.4
Stock Numbers - cows wintered/cows milked	2.0	1- 3	100	1.0
Drenching: dose, product, date	2.0	1- 3	60	1.4
Paddock grazing	2.1	1- 5	50	3.0
Heifer weights	2.1	1- 5	60	1.2
Cow condition score	2.3	1- 3	0	1.4
Pasture cover (DM/ha) - each paddock	2.4	1- 3	0	2.4
Drying off date	2.4	1 - 4	60	1.0
Soil temperature	2.5	2 - 3	40	2.6
Pugging damage, assessment and date	2.5	1 - 4	10	1.8
Animal health treatment	2.5	2 - 3	60	1.6
Nitrogen applied (areas and rates)	2.6	1 - 5	100	1.2
Regrassing - species, paddock, date	2.6	1 - 3	50	1.2
Herbage test results	2.7	2 - 4	60	1.6
Minerals supplementation: product, rate, date	2.7	2 - 4	50	1.4
Spraying: product, paddock, rate, date	2.9	1 - 5	75	2.1
Water quality	3.0	1 - 5	10	2.4
Stock losses and reason	3.1	1 - 5	90	1.4
Hay/Silage: when paddock shut up and cut	3.3	2 - 5	40	2.2
Pest, insect damage	3.3	1 - 5	0	1.2
Heifer grazing off (dates, location, cost)	3.3	1 - 5	60	2.0
Rainfall daily	3.4	2 - 5	50	2.2
Effluent disposal	3.4	1 - 5	10	2.0
Stock sales ($)	3.5	1 - 5	75	1.8
Hay/silage: amount made	3.6	2 - 5	25	1.4
Supplements fed	3.6	2 - 5	10	1.6

Considerable effort had been expended by the group on developing an information system, including the use of a self-designed questionnaire to determine group information needs (see Table 6.1). While discussing their responses to the questionnaire, a growing sense of despair prompted a watershed in group commitment and purpose. The Environment Waikato member concluded from the self-assessment survey results that information requirements and dairy production emphasis in the group expressed little concern for resource management issues. The member from Environment Waikato therefore planned to leave the group meeting early, with little intention of further involvement. This threatened withdrawal of Regional Council involvement placed further stress on the LIC facilitator who was grappling with the interactive communication methods required in collective learning programmes. The facilitator's experience was grounded in conventional dairy discussion groups, where debate was usually created among farmers using recent research reports from the DRC and Massey University. Researchers were also uncertain about the use of collective learning processes, considering them the cause of much obscurity in group purpose and engendering unnecessarily high risks to the programme. Farmers were only willing to attend subsequent meetings if there was evidence that more direction and purpose was emerging from the group - they still expected *to learn something from the scientists.*

As the group struggled with the issue of information support to farmers, members reflected on the purpose of the programme and farmer needs. This reflection was evident in an heated discussion on riparian management and stock movement in the field in November 1995.

> *'G-- [*the Environment Waikato representative*], I was very pleased you stayed because I was feeling like you at lunch time - why the hell am I here? Here, but not actually doing anything and resource management seems to be miles away from where we are at. That talk that we had over lunch helped me on two things: the talk about the Landcare groups and what we have here. The Landcare groups are very much centred around an issue and an activity to clean up that issue. The issue is an observation of the scene. Landcare groups actually see dirty water or they will see slippages. The groups that we are working with both here and up on the hill don't have that straight forward observation. We could walk through those farms for ever and not find anything particularly outstandingly problematic about resource management for the group to actually focus up on. But what it did say to me was that why are we bothering to record and the main reason that we wanted to record as a group was for a demonstration to others.'* (Programme Leader).

During this discussion L-- discovered that farmers used information in an holistic way[8] to make their decisions.

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[8] For example, *'I think it oversimplifies things if you write it down. There are too many other variables that come into it and I like to calculate them as well. If I employed someone then I would work this system, but we have been on the same farm for a while now. We have worked together, my wife and me, and we probably rely a lot on experience. Do you think it is something that you are continuously looking at if you are writing it down? Unless you are doing it at the same time every day or whatever, you are getting continuous information on grass cover with the farm walk aren't you... your pasture cover is relative to what else is going*

'But in fact what the farmers came up with today, which really changed my views as a science person, was they are actually integrating all their observations. So they don't need to record condition score and pasture cover or whateverelse because they have some umbrella index, like the fertility index, that they use as guide to where their farm is. So in the computer, in here [points to her head] *they have taken all these little bits and they are assimilated into a whole farm index - whether they are happy enough with that index will determine if they'll do their management one way or the other. Now if we are going to record the individual things that we have talked about that is not going to be enough because they tend to integrate those things - and its the same with science. We might do organic matter or pasture composition or whatever but in fact its all of those things together that are actually going to give us the answer. And so I am not sure now whether the recording of these individual things is really the mind set that farmers have. Therefore we maybe setting off down the wrong track, to say you should be measuring these individual things because farmers are integrating all of these things. So that was one bombshell.'* (Programme Leader)

The Programme Leader then moved to the implications of using integrating information in group work.

'And the second bombshell was that, talking with M-- as we were moving through the farm, what we do is say bring your diaries or whatever it is. If we had just stuck with that discussion on diaries these guys would have brought nothing next time because they don't use diaries. They use maps and they use the back of the bike and they use whatever - it was that language thing again. So we don't want to use the word diaries, just say whatever you use to think about the topic, whether its your brain or whatever just bring it. What we need to be doing is expanding that farm walk at our meetings. Instead of spending a lot of time indoors, as we do normally, we may be better to be spending a lot more time outside at a certain time in the season when everybody has an issue that they are getting concerned about. And they have got whatever records they have with them, and they then say how to link production with sustainability using their observations. And its maybe there that you start to say whether we need to record something. How they demonstrate to themselves and to others that they have something is the issue.' (Programme Leader).

As a consequence of the debates in the evaluation session, the Environment Waikato representative agreed with the programme leader that past emphasis on recording and group information systems had been framed according to the norms of reseachers and professionals and failed to appreciate the world of the farmer. This failure to gain sufficient empathy with the farmers worldview affected subsequent planning of group activities. It was agreed the purpose of the group need to be worked through with the farmers at the next meeting. The group did not meet again until February 1996, until this time programme leaders and Environment Waikato members reflected on planning methods for the following year. Several meetings were held among the researchers and professionals to determine how to respond to issues of farmers needs and group purpose. Topics that were discussed throughout the year were reorganised as themes. Each theme was tabled as an alternative for guiding group work. Programme planning was to be organised according to the central tasks that emanated from the use of the theme selected by the farmers.

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on as well. That the soil temperature is on the up and the grass is starting to grow, you've applied nitrogen perhaps.' (Farmer, Nov95sg)

The February meeting was the first for the new year, and aimed to move the onus for group purpose and activity planning from the professionals and researchers to the farmers. A belief mapping procedure was used to assist farmers work through the implications of each theme for group direction before making their selection. The procedure had farmers brainstorming to generate a list of issues pertaining to resource management and farm production. A facilitator from outside the group was employed to run the brainstorming session and organise issues under the direction of the farmers. The group worked from their collectively constructed belief map of the farm system to account for regional, national and global issues that had some bearing on their farming. The selection of a theme was therefore based on that theme which encompassed most of the identified issues. This exercise determined nutrient balance as the critical theme for the dairy study group.

Farmers responded to the theme selection process by making many suggestions that later developed into opportunities for undertaking joint work on the issues. What began as work on a programme managers:Environment Waikato planning problem in late 1995, became a group planning activity focused on farmer needs in February 1996. All members were actively developing the group plan.

Furthermore, the work that ensued from this planning activity had all members interacting on the gathering and analysis of data, that in itself engendered a sense of a group identity. For example farmers, professionals and researchers worked on issues like nitrogen monitoring in pastures where no one individual had complete confidence in their routines for managing nitrogen. An ensemble of development requirements pertaining to hardware and methods was explored as members contributed towards the building of joint work on the issue.

G-- = resource management advocate
M-- = soil scientist
L-- = programme manager
P-- = farmer
Mk-- = farmer
D-- = consultant

G--: *If we did go into pasture sampling, however many times per year it was required, aren't we saying that it will be two or three years before we actually got a reasonable figure that we could use in a nitrogen balance because of seasonal variations, yearly variations, variations per property and per paddock.*

M--: *I think we'd get a bit of a feel for it after a year.*

G--: *Okay.*

L--: *What would be interesting is using the power of the group information - because everybody in the group does it for a year you might find for instance that this or that area all pans out very similar. If you've got similar fertilisers, or similar numbers of animals, or whatever.*

M--: *That's right there maybe some problems in some areas of some farms that are quite variable.*

P--: *We're either all going to do it or nobody is going to do it.*

All: *Its got to be that way P--.*

Mk--: *So we just take a sample is this right or are we doing the dissecting and the weighing and everything.*

P--: *Its possible we can do the whole lot but whether we are prepared to put the time into it.*

L--: *You could either decide within the group that you're going to take turns maybe bring it back to a central person in the group to do the dissections for you.*

D--: *Its also the oven drying facilities.*

L--: *A microwave would do it.*

D--: *What about scales for weight afterwards.*

L--: *That would be easy if we knew when you were doing it, we just bring the scales along.*

G--: *Hang on a moment. We will end up with a percentage of clover we've got to know how much our production per year is to multiply up. How are we going to know what that is?*

Group cohesion intensified as members organised themselves to gather information they considered necessary for reflecting on their farming. Often this involved a willingness to take risks in anticipation of shared benefits from working together. For example, time is often a critical resource to many dairy farming families, yet these farmers were willing to commit themselves to tasks for the group that may take several seasons to return practical benefits to their individual farming operations. Interdependence with other members, like trust in the judgements of the researchers, helped the group to cope as a whole with these risks and uncertainties.

Researchers also gained new ways of operating in the collective learning situation. Often the tools of the researchers were designed for specific tasks and were not readily used in farming. The researchers depended on the farmers, as potential users of the tools, to adapt tools for use in farming. Working together to modify tools for a shared purpose also fostered a shared identity. At times the sharing of joint work challenged a member's sense of identity that was grounded in previous or concurrent work situations. An indication of this identity challenge occurred when farmers and professionals in the group were working through nutrient budgeting calculations using a software package built by researchers for regional analyses. Farmers were quick to argue the need for a more relevant tool for farming that accounted for the variability between properties. The group also aimed to monitor a wider range of nutrients than was possible with the regional model.

M-- = Scientist
N-- = Farmer
D-- = Consultant

M--: *My worry with these budgets is there is pressure on our systems to look at budgets and the bigger picture, to look at budgets you know at the regional and the*

international level, and before you know there are a couple of computer experts that are doing it all themselves and they don't ...

N--: *They wouldn't know what a cow looked like.*

M--: *You have to come up through the system to understand it.*

D--: *What about policing their findings.*

M--: *Yes, policing their findings, so this is really good.*

The group became important to the researcher as a resource for improving his performance as a researcher. He began to review his research work and modelling activities in relation to the experiences and activities he could access through working in the group. His research gained benefits of relevance through working in the group, and the group gained access to research methods and hardware because the researcher was dependent on the group.

4.2 Critical Issues

A muddling through towards greater clarity of study group purpose did not imply the neglect of the programme mission, on the contrary, the mission of the programme was refined through a regular revision of activities and achievements. However, muddling through is a risky strategy for programme management as it involves a repetitive plunging into unknown territory that can unsettle newly established routines. It was the breaking of routines, both in group work and in farming, that provided new opportunities for change towards the alignment of resource management and production goals, but it may also undermine group cohesion.

Comparing the work on the construction of a general information system for the group, with the weighing of stock or monitoring of nitrogen, identified a requirement for work to be directed at the specific needs of members. The work on building a general information system failed to offer tangible hardware or methods for other groups, but it assisted members in the study group to make their needs explicit. This in turn heightened the crisis in group cohesion, brought about a new appreciation of information by some, and consequently renewed planning efforts towards the building of new work activities. It was the joint planning activities performed by the Environment Waikato and programme leaders that fostered a shared identity where previously conflicting goals dominated debates. As in the previous stage of the programme, a crisis preceded reflection on the activities of the group.

Time was required to modify the collective learning procedures operating in the group and re-focus the overall programme. The way the themes were developed and used in a planning exercise provided sufficient flexibility for all members to work out their needs in relation to group work plans, while imparting a general sense of direction and purpose. A combination of brainstorming, belief mapping and debating around the themes identified needs that were critical to all members, in particular, those resource management and production concerns that were sufficiently uncertain as to require collective effort from research, farming and the professions towards the improvement of farming methods. This re-focusing exercise was performed after a period of one

year's sensitisation to the general problem of aligning production and resource management goals. Study groups probably require *incubation* periods to work through complex problems of this nature.

Working together on the nitrogen issue built a confidence to act amid the uncertainty of limited experience and information about nitrogen cycling characteristics in pasture. This confidence was derived in part from the sharing and assembling of hardware and methods that imparted a self-perpetuating boldness to make a commitment to work collectively on the problem. As the members accessed each others' *toolkits* they built a shared identity - an awareness of new possibilities when working together, where previously they could not have acted if they were working in isolation. However, the building of new working relationships can influence and possibly undermine old ones.

4.3 Emergent Learning

Muddling through the problems and opportunities that come out of efforts to align resource management and production goals is necessarily risky if progress is to be made on such complex problems - the absence of routines and rules means there are many opportunities for errors in performance. One risk of muddling through with study groups is a deterioration in group cohesion. However, apparent failures can contribute in unforeseen ways to an overall attainment of study group purpose. Working as a group to build a common information system did not achieve its intended purpose (an information system) but made explicit the differences in members' needs.

Study groups operate to build substantive achievements on problems like nutrient cycling. Periodically a group will review its inter-active performances. The study group is therefore an interface for the interplay of practices. The needs of members are specific to the practice they perform in, requiring the group as a whole to work with problems at a level that can align needs pertinent to all practices interplaying at the group interface - referred to as an emerging broker practice. This broker practice is more capable of reducing uncertainty in the alignment of resource management and production goals than the practices operating in isolation, but will also periodically require the use of a mediating practice to reduce uncertainty about the alignment of practices. For example, a mediating practice will facilitate problem selection activities - to identify problems that are critical to members, and at times complex, being both the justification for collective effort, yet relevant enough for each member to identify personal benefit from working jointly on the problem.

Collective learning involves the processing of possibilities for a practice. It is the actors who perform the possibility processing activity in as much as commitment is shared among actors who possess a confidence to act when the consequences of action are uncertain. An expanding interdependence among practices at interplay has a corresponding growth in trust among actors.

5.0 Integrity

5.1 Significant Events

By June 1996 the farmers in the group had accumulated sufficient evidence about their methods of farming to alter their stock management routines towards a reduction in pasture pugging. Furthermore, they had identified the task of balancing nutrients in the soil:pasture system as an area of uncertainty in their farming and were developing sophisticated nutrient budgeting techniques in conjunction with the professionals in the group. These achievements were documented and distributed as supplementary articles in the Farm Practice Guidelines, and incorporated into the information bulletins and science papers written by researchers in the group. The work of the group culminated in a public field day run by the farmers to demonstrate their methods and achievements for their farming community. Administrators in funding organisations recognised the programme as a success in terms of collective learning and documentation of change management. This section explores the emergence of integrity in the study group as members worked together to develop farming methods, and to communicate their work to interested others as required by the programme funders. An initial understanding of integrity is taken as, *'Integrity includes both one's sense of membership and loyalty and one's sense of moral autonomy. The very word suggests "wholeness," but insofar as one's identity is not that of an isolated atom but rather the product of a larger social molecule, that wholeness includes - rather than excludes - other people and one's social roles. One's integrity on the job typically requires the following of the rules and practices that define the job.'* (Solomon, 1992, p.168). An elaboration of this initial position will follow using the case study analysis.

The sustainability programme was dedicated to extending[9] its achievements to interested others. Features of the programme design were adequate for extending information as paper documents generated by group efforts to develop new farming methods. The pugging information was disseminated using the grazing guidelines, workshops and popular articles in the farming press. Bulletins published by the organisations involved in the programme were used to profile the work and achievements of the group. Over time the study group used local television and radio media. These media were adequate for reporting outcomes from the group, but more difficult for the programme leaders was imparting the joint working experiences that achieved the outcomes.

Extending programme outcomes to interested others was a prerequisite under the funding agreements. Furthermore, members in the study group had a desire to share their achievements, partially to legitimate their novel programme before nonchalant observers, but also as a consequence of their mounting enthusiasm for acting on resource management issues. Yet members considered that extending factual information on farm management methods was less significant than extending the processes responsible for their development. Programme leaders considered a more significant extension activity would involve the sharing of group reflections about

[9] Extending here refers to activities that impart to others, a way of giving or bestowal, that in turn enlarges the domain of the programme influence in the dairy sector

their learning experiences in relation to emerging farming methods. In this way they hoped to impart to interested others an appreciation of the interplays necessary for the emergence of practice. To convey an evolutionary perspective of interplays and programme achievements required role modelling before conference audiences (Paine, Wedderburn and Cotman, 1995). Role modelling was a dramatic portrayal of how technical information was generated, as if in the field, before a conference audience. Extending became an interactive activity.

Programme leaders discovered a market existed for the information emerging from the work of the study group. Reports of group activities and achievements were sought by farmers and policymakers. Pugging guidelines found a ready market, and programme leaders were remunerated for their contributions to the public, and to government policy workshops. Intellectual property (IP) accumulated in terms of programme outcomes, and as demand grew from a credible track record on confronting issues of resource management. Revenue generated from the sale of IP was minimal, being received as remuneration to the programme leaders for the additional personal investment made to promote and ensure the success of the programme. The programme was not designed as a revenue generating initiative, but as a contribution to a public good. The expectations of funding organisations' were of a public good nature, though they were not averse to consultancies emerging from the programme. Although no consultancy work was contracted by the programme at the conclusion of this study (June 1996), the programme provided track-record for researchers to successfully bid for the funding of several new programmes.

How did those study group members who were employed by organisations convey group experience to their colleagues? Group members from some organisations participated in the programme as an extra task over their routine duties. Some AgResearch and Federated Farmers workers were an exception to this situation. The members from organisations who were not funded by the programme were confined to local level contributions towards the programme. Management in these same organisations did not seek regular reports or formal contributions from the programme in terms of say staff development workshops in return for their investment. The professional members in the group were field staff in these organisations who had relatively inconsistent connections with their colleagues, compared with the permanent regional or central office staff. The evolutionary design of the programme meant interested others within organisations often received sporadic and unstructured feedback on programme developments and achievements. Programme achievements may have appeared discontinuous, unplanned and poorly co-ordinated to the staff in unfunded organisations. By way of contrast, management in AgResearch and Federated Farmers organisations made positive structural changes to support the programme. Group members from these organisations were allocated time to support the programme, and performance awards were linked with programme achievements. In return the study group was frequently used by AgResearch to profile the organisation in new bidding arenas, and provided a public relations vehicle to demonstrate that AgResearch was active in participative R&D work. For example, AgResearch managers were working on the development of a collaboration R&D programme with Missouri University. The study group was used, along with other AgResearch programmes, as a concrete example of collective learning to address

issues of resource management in relation to agricultural production systems. Similarly, Public Good Science Fund (PGSF) proposals used issues that emerged from group work to design sustainability research programmes.

Members who were initially advocating an emphasis on production goals evidenced a convergence with advocates of resource management as they worked through the development of farming methods. Correspondingly, the Environment Waikato staff altered their perspective of the programme following the end of year watershed meeting to take a leading role in group learning activities. This change in perspective was accompanied by a growing appreciation of the interdependence of practices to satisfy production and resource management goals. Similarly LIC staff had a growing respect for natural resources like clean waterways. Farmers acted as integrators of the various professional positions taken toward production and resource management.

> *'We learnt a lot from the scientists', says Peter, 'but I suspect they may have learnt more still from us. Everyone is pulling in the same direction, and its been an opportunity for everyone to gain access to the scientists and with up to date research. Often in the past we haven't understood each other and we're now finding more common ground.' ... 'This is an opportunity to be more pro-active and give informed feedback to Environment Waikato.' ... 'I want this land to be farmed another 50 to 100 to 200 years but the RMA could make it hard.'*
> (The North Waikato Tatler, Wedn 22 May 1996, p.10).

Earlier in the life of the programme farmers had expressed instrumental needs to align resource management and production goals, such as the support of family needs and to operate viably in the long term:

> *'We are stewards of the land, we have to be here for a few years yet. We have to get our kids through university. Hopefully when the kids come through they are still going to be able to make it profitable... We hope to be around a lot longer than when our parents were on the farm too. We haven't got superannuation funds to retire on so we have to look after our farms to last us our lifetime. We can't say we are going to quit milking when we reach 50, we've got to keep going.'* (Farmer, Sept 1995.)

Coinciding with these instrumental needs was a style of participation in the programme that sought to justify routine methods of farming. The farming members expressed confidence in their methods, but doubts about the understanding that 'greenies' and interested others had of 'real' farming:

> *"We can measure the economic things I suspect. Looking at it from my position in this thing* [the programme] *our big problem is how do we measure and decide whether something is worthwhile from a sustainable environment point of view. I would suggest a lot of us do a lot of things because we believe they are worthwhile, we know they are environmentally sound but how the hell do we prove it to L--?* [The Programme Leader]*"* (Sept 95);

However, as resource management and production needs were integrated in the study group, doubts were expressed about what constituted good farming. Farmers were judging the work of other farmers in terms of resource management and production rules:

> *"I've a neighbour who's growing maize for silage and selling it off. He's on peat and he's been doing this on a regular basis, and now he's putting 1 tonne of N on. Everything is going off and he's just loosing the nitrogen out of it and its costing a tonne of N this year to put the nitrogen back in to keep the maize growing. So that's a*

real extreme example of what can happen and whether he is putting too much on or not enough, who knows?" (Feb96).

The substantive concerns of farmers shifted from a need to prove to others their systems were environmentally sound, to a genuine inquiry into environmental issues. Programme leaders were initially viewed as the target audience to whom farmers had to prove their systems. Later, farmers shared problems with other group members in an effort to resolve their farming concerns.

Group operational procedures also altered as members gained familiarity through working together. At the initial meetings the facilitator specified ground rules for group conduct, after several meetings these were no longer needed as members routinely interacted with mutual respect, and sincerity. Furthermore, members evidenced the implicit use of give and take rules as they worked together. When researchers from Missouri University wanted to observe the group in action, a special meeting was called, at a critical time in the NZ farming calendar.

'They showed a level of commitment in that they agreed to have this meeting for the people from Missouri, and they will be calving by then. It was a favour from them and they understand that there is give and take.' [Programme Leader]

This visit by the Missouri researchers also evidenced an emergence of group identity through interdependence in both work activities and language.

Missouri Researcher: *Have you got a way of monitoring - are you monitoring forage growth?*
Group Researcher: *That means pasture.*
Farmers: *Yes and do.*
Farmer: *I monitor growth rates but I rely on the scientists to tell me how much grass I'm growing per annum and things like that.*
Other farmer: *So we realise at the moment that grass isn't growing as quick as it might do. It's reasonably warm now for this time of the year, we expected the grass to be growing reasonably well but it doesn't seem to be.*

Group cohesion was also evidenced in the frank communication styles used by members who were enthusiastic about their message of ***resource management through farming***. In a meeting that reviewed the achievements of the group's field day (see below), the farmers debated their role in public forums to profile programme outcomes. The farmers concluded they had a legitimate role in contributing to the credibility of the programme, particularly when the outcomes were applied to the situation of other farmers. Professionals in the group endorsed the conclusions that their farming partners reached in the debate:

T-- [Farmer]: *'I think the bottom line is that you've got practical farmers up there presenting it and, well no disrespect to say the core experts, but farmers like listening to farmers because its hands-on experience. It means a lot more coming to you from a farmer. You could say the same two things but you tend to believe Mk--* [Farmer] *more than you would M--* [Scientist]. *You know the guy is out there doing the graft and that's the bottom line. You've still got to have the expert there because he gives you the backup I suppose with trials etc., but to me the farmer is the most important.'*

Mk-- [farmer]: *A few comments I got were the other way, my speech was hum drum run-of-the mill stuff and what M-- had to say was gospel.*

> P-- [farmer]: *I disagree. If we had just the science side its not going to have the impact it does with a bit of practical farmers experience as well.*

On 25 May 1996 the group launched a public field day before an audience of 95 farmers, agribusiness and policy makers. An emphasis on farmer experience had three farmers as the keynote speakers delivering the message of the group to the public, supported by short presentations by the professionals.

Farmers in the group designed a brief questionnaire, with support from the researchers, to survey farmers and others attending the day (see Box 6.2). Farmers in the group were encouraged by the survey results, and by informal feedback that public impressions of the group were consistent with the activities and intentions of the programme. Furthermore, they found simple descriptive surveys reinforced their position with funding organisations.

Box 6.2 Survey Results of Farmers That Attended the Field Day

Total numbers attending field day: 95
Total numbers responding to questionnaire: 66
Total number of responding farmers: 44 from 37 farms
Total Farm Area: 4722 ha

Questions

How the farmers heard about the field day
Rankings
1. Rural Delivery mail out
2. Other (radio, television, newspaper)
3. Networked through discussion groups in the area

Why the farmers came to the field day
Rankings
1. learn about sustainable farm practices
2. acquire new ideas
3. for a technical update

Farmers in Discussion Groups
26 members of a discussion group
18 not members of a discussion group

Reasons for Attending Discussion Groups
Rankings
1. A source of technical ideas
2. For personal motivation
3. For social sharing of experiences

Understanding of the Purpose of the Dairy Study Group
Ranking
1. Get scientist input to practical farm problems
2. Get farmers to measure factors affecting their farm performance
3. Motivate farmers to lift their farm performance

How Farmer Intended to Judge the Day
Rankings
1. Based on the new farm management ideas gleaned from the day
2. By the way I change the management of environmental issues on my farm
3. By the way the meeting motivates me in my own farm management

5.2 Critical Issues

The problem of resource management and farming proved sufficient to inspire a continuity in work effort among study group members. Group work operated in two dimensions. In one dimension their activities were building new methods of farming,

while in the other dimension members were working to extend to others the message emerging from group activities. It was the extending work of the group in particular that had implications for the integrity of the group. Integrity referred to identity through group membership, having both moral autonomy and social integration ramifications for members. When some members were extending 'the message' they were representing the works of others in the group.

To extend the group message required more than releasing information through conventional media, or even accessing high impact media like television. For example, members sought to convey the building of practice through action and reflection on action using role play techniques in conferences. Using unconventional communication methods proved to be a risky and uncertain endeavour, similar to the muddling through experiences that renewed the group purpose in the earlier stages of the programme. Notwithstanding these risks, a market emerged for the information offered by the group. Fees were paid to access the professionals and the researchers who worked in the programme. Funders did not consider the payment for services violated the public good nature of the programme, on the contrary, consultancy opportunities were viewed as an effective means of further extending the impact of the group on the sector.

Extending the study group message included the way professionals and researchers worked with their colleagues within their respective organisations. A difference was observed between contributions from funded organisations compared with unfunded organisations. Those organisations that operated on a fee for service basis to make contributions to the programme had high expectations and were committed to leveraging benefits from the programme. These benefits included using the programme to profile the work of the organisation and attract further funding on the basis of track record in the programme. Leveraging off the programme connected the organisation and the programme towards a common identity.

The alignment among members within the programme also strengthened through the work of the study group. Working on the development of farming methods convinced members of the interdependence of the practices performed in the group. The time dimension of the problem, linked with perceived threats of regulatory intervention on farming, provided an immediate recognition of a need for common action on resource management issues. Initial goals were expressed as instrumental concerns, combined with a justification for the use of routine farming methods. Subsequently doubts were expressed about some farming methods, which moved these methods to centre stage in study group development work. It was the expression of doubts, rather than bold claims of confidence, that revealed the harmony in the group. Members had sufficient confidence, commitment and dependence on others in the study group to expose doubts as a means of creating new possibilities for collective action.

The study group also evolved its rules of working together. The use of basic ground rules was later unnecessary as an expanding familiarity and trust among members proved sufficient for working together. Members implicitly understood the rules of 'give and take' and the performance of frank criticism as part of the study group process. Furthermore, members helped one another by mediating to span difficulties

such as language, as in the situation with the from the Missouri researchers. This mediating was performed with humility and respect among the members, no one member considering themselves less significant than others in the study group.

The study group justified its performance by extending a message of resource management through farming that needed an interplay of practices from farming and research. Identity, as corporate security through collective action as a study group, emerged from both building a practice and extending the content of the practice message to others. In all this, the farmers evaluated their work as of routine, developing their own methods of evaluation during the development.

5.3 Emergent Learning

Defining a problem that has sufficient scope to provide purpose for both an interplay of practices and an integration of sector needs is a critical design consideration when working on complex issues like resource management. Correspondingly, an emerging integrity among the actors - those who work in practices that interface at study groups - capacitates programmes to make progress on these complex problems. When actors attempt to extend their activities to others not operating at the interface, they often confront uncertainty about the relevance of their practice for new situations, and uncertainty about the efficacy of their communicative methods. These uncertainties provoke the building of integrity - whereby **doing is being** - such as occurs in role play situations at conferences or public field days to convey the active lessons of resource management.

The issue of IP and its allocation within programmes is not a complex problem when integrity is developing in study groups. Rather, the conventional mechanisms for exchanging IP like consultancies and fee for service arrangements are usefully integrated into programmes that generate saleable information. This information represents a spin-off from the primarily public good endeavour of aligning resource management and farm production goals.

The integrity of actors extends beyond the bounds of the programme, through the work of the programme. When the staff of organisations are funded at market rates for their contributions to the programme, structural arrangements can operate whereby organisational communities extend their commitments and expectations. This extension of commitment operates for the benefit of the organisational community, which can leverage off the programme, and for the programme, by extending access to additional organisational resources.

The interplay of practices in programmes is performed using rules of working together. These rules specify how give and take negotiations are performed, when frank criticism is necessary and how it should be conducted, and who mediates for who when interplays are stalling. When programmes operate to effective working together rules, an identity of interdependence emerges. Members, as practitioners of practices derive a corporate security. In these situations a programme can propagate a broker practice. The rules of working together are the rules of play for a mediating practice.

6.0 Conclusion

The activities and experiences of the SSGP evidenced fluctuations in the strength of group cohesion depending on the clarity of problem purpose and the linkage between the general problem for the group and the needs of the individual actors in the group. This case study identified that the problem of alignment among actors is symptomatic of a more fundamental problem. The underlying cause of alignment problems in programmes are the errors performed in the interplay of practices. Study groups provide an interface situation for practices to interplay. It was when the programme leaders and Environment Waikato staff undertook a fundamental reflection on the overall purpose and direction of the programme, using themes and building topics and activities around these themes, that the group evidenced a sustained activity towards the development of new farming methods.

Working together on pugging problems and the balance of nutrients in dairy pasture systems was, as in previous case studies, characterised by a muddling towards an outcome of general relevance to members and interested others observing the activities of the group. This muddling through regularly confronted uncertainty about the likely effectiveness of new farming methods, and about the likely ease of working together on the above problems. One of the greatest uncertainties pertained to extending the work of the group to those outside the group. These uncertainties provoked doubts and reflections on actions that tended to strengthen interdependence among practices and to strengthen the corresponding ties among group members. As practitioners worked to resolve doubts and reduce uncertainties they derived corporate security - doing was being - and practitioner integrity derived from performing in an orchestration of interplaying practices. Integrity comes out the performance and combines the aspects of competence. This competence is an elusive phenomenon in practice, being the realm of most interest to philosophers like Gremmen (1993). It was in the integrity of the practitioners that they positioned their work for ease of interplay, such as the reworking of the nutrient balance models; it was integrity that had practitioners representing their work to interested others in field day situations; it was integrity that had practitioners judging the works of others in the group, being bold but sensitive in their frank criticisms. And it was with strategic integrity that practitioners combined stock movements with monitoring and modelling (cognitive and hardware), in group debates (social) for farming. Integrity combines the aspects of competence and is related to the aspects of performance through strategy.

Integrity operating in the interplaying of practices empowers group members to strive for more realistic portrayals of their work to others. Integrity has members using high risk theatrical performances, which if successful extend the programme in both content and in enlisting others, rather than just relying on routine information sheets. Integrity is an outcome of working together, but its emergence in the group enables new possibilities through new performances.

This concludes the series of case studies, analysed in terms of practice using the interplay model. Findings from the case studies have several implications for the revision of the Interplay Model, and for the subsequent use of the model in the

management of theatres of innovation in the Dairy sector in NZ. These implications and applications are developed in the following chapter.

Chapter Seven

Managing Technology: uncertainty and strategy

'We don't know whether it is possible for societies to live and prosper with advanced technology. This is an uncertainty at present.' (Lord Ashby)

1.0 Introduction

This chapter uses lessons from the previous cases in an elaboration of technology management challenges in theatres of innovation, in particular, managing in a theatre of innovation where no specific organisation or actor performs an overall coordination or leadership role, as in the NZ dairy sector. Change is continuous in theatres of innovation, though as outlined in chapter three, the extent of change in the NZ situation has seen many new organisations and the creation of new responsibilities for these organisations as a consequence of recent government policy. Many of these organisations face strategic choices in terms of how they position themselves to perform in a theatre. The performance of organisations in a theatre of innovation therefore extends beyond a separation of providers, users and funders of scientific knowledge. Rather, the use of a practice analysis emphasises harmony in the theatre as a critical outcome for all actors and organisations to work towards when performing their routine work. This chapter will explore how an analysis of practice may contribute towards resolving problems of harmony in a theatre of innovation.

The chapter opens with a discussion of uncertainty in the theatre, and the place of strategy as an active response to the problems and opportunities arising from uncertainty. Developing a perspective on strategy for managing action in the theatre of innovation first requires an elaboration of the practice position developed in this thesis. This strategic managing of activities is applied at the level of programmes and organisations that operate in theatres of innovation.

2.0 The problem of uncertainty in theatres of innovation

2.1 Uncertainty

In each of the case studies, the actors performed with incomplete information about the biological systems with which they worked. Actors working on the CIDR device were uncertain if prototypes would work, and if so, whether it was possible to produce the device at an economically feasible scale of production. In the case of the SAMM, actors worked to minimise the uncertainty of product failures due to food safety and product quality criteria. Similarly, the actors in SSGP confronted uncertain farm system responses to their use of new methods of pugging management and nutrient budgeting. In constructing responses to each of these uncertainties relating to biological systems, the actors confronted a concomitant set of *theatre of innovation uncertainties*.

The AKS perspective emphasised knowledge and the use of learning procedures, in social settings that are often inundated with information, as a means of co-ordinating activity in the theatre of innovation. The ToT, chain link or PAR models all specified types of methodologies for aligning actors in a theatre of innovation towards co-ordinated performances. Similarly this study is concerned with the problems of harmony that emerge in substantive domains of actors, their networks, and the tools they use to perform under conditions of uncertainty. However, where the analytical point of departure in this study differs from the perspectives previous discussed is to treat action as the object of analysis, and in particular, action analysed as practice.

The analysis of practice is discussed further in section 2.2. Suffice to say here that the theatre of innovation is used to refer to that domain of human activity that is primarily concerned with the construction and use of information in agriculture. A theatre of innovation subsumes those components of science, agribusiness and rural communities that pertain to information systems. An analysis of practice enters this theatre of innovation by viewing actors, organisations and programmes as interfaces where practices align. By analysing practice, apparent failures to attain synergy among actors or organisations in a theatre of innovation is explored in terms of errors performed in practice interplays. The term synergy implies a mechanistic quantum of actor ability to act that exceeds the sum of the individual actors in the system, as first used by Ansoff (1965). Synergy is replaced with harmony in a theatre of innovation. The latter does not imply all actors work co-operatively to construct and use information. Under harmony the actors in the theatre of innovation know when to act co-operatively and when to act competitively - harmony reduces the uncertainty of interaction among actors. Harmony is not synergy in a theatre of innovation, rather harmony is consistent with the theatre metaphor, inferring creativity, explosive potential, and interdependence of each actor on the stage to create a living message - each play being a unique rendition of the rules as laid down in the script.

Uncertainty in the NZ dairy theatre of innovation was observed in each of the case studies. The CIDR case study identified the professions, like veterinary and consultancy, which often had problems of alignment such as the delayed involvement of veterinarians in development work, the attempted displacement of veterinarians in

farm servicing and the partitioning of risks, responsibilities and rewards of servicing farms with synchronising technology. Professions became vulnerable as they became increasingly transparent to other professions through the interplay of practices. A shared professional integrity was a countervailing force that ensures professions are aligned in the theatre of innovation to perform synchronising service. The place of integrity is the theatre of innovation is developed further in section 3.0.

Events in the SAMM case study were by-in-large conducive to harmony in the theatre of innovation. The risks to the sector of neglecting to manage uncertainties in the biological system were blatant to all the relevant actors dealing with milk production and food safety. Furthermore, no single organisation or profession claimed full responsibility or competence for managing these risks. The early activities and networks among the actors in the theatre of innovation were sufficient to enable the establishment of more formal agreements without inhibiting professional autonomy or innovation. A practice of mediation operated to harmonise the interplay of practices that worked on mastitis management. The place of mediating practice in managing interplays in the theatre of innovation is elaborated in section 3.0 below.

In the SSGP case study the actors had to deal with uncertainty in the theatre of innovation in two dimensions due to the obscurity of the resource management problem. In one dimension actors were building a broker practice for sustainable resource management through farming, that at times experienced an uncertainty of identity and programme purpose. In a second dimension some actors in the programme were also struggling with the obscurity and development needs of a collective learning process that was expected to build the rules for actor interaction, and thereby foster the interplay of practices. Herein lay the problem of uncertainty, for some would argue the interaction of actors follows the interplay of practices. Indeed, the latter was the case, as it was the construction of pugging and nutrient balance information that expressed harmony in the programme and enabled the programme to extend activities more widely in the theatre of innovation. That actors worked on nutrient balances, but not water quality, was indicative of their willingness to take action on issues they perceived had possibilities for improvement. Again an integrity of practice emerged as shared work spawned a collective doubt about the way biological systems operated, and fostered a need to act to resolve these doubts.

Problems of harmony in the theatre of innovation were also noted in Chapter Three in relation to the NZ context for the above studies. With the restructuring of the science system came organisational and actor uncertainty. Distinguishing among the providers, purchasers and policy-makers for research, science and technology (RST) was intended to improve the alignment between organisations in the theatre of innovation. The CRI were expected to structure themselves to serve the productive sectors in which they had track record and comparative advantages in terms of hardware and methodologies. While connections between the CRI and the sectors may have improved, there is often conflict between and within CRI R&D groups. Indeed the CRI as organisational entities continue to work out their purpose in terms of providing both a centre of excellence for science, and for performing as economically viable research companies. Yet these concerns are just one facet of the issues in the wider context of the theatre of innovation, where the recent free market

policies have had immediate effect. The reduction of subsidies, both directly in terms of risk management in price support and disaster relief, and indirectly in terms of reduced interest rates and provision of extension services to farmers, altered the rules for interplaying practices. To give some idea of the rate and magnitude of these reductions, direct state subsidies reduced from $1192 million in 1983 to $116 million in 1993 (Cloke, 1996). One farmer succinctly described the new rules for farming as a consequence of the changes:

> *'The government untied the ropes on one hand, by giving us economic freedom in which to operate, but they bloody well tie you up on the other hand. This Resource Management Act means we'll have to crawl over the new 'greenies' to do anything on the farm.'* (In Cloke, 1996, p.311).

The concerns of the farmer above were similar to those worked through in the SSGP. However the free market impacts on the dairy theatre of innovation were not as severe as other pastoral farming sectors, particularly sheep and beef, as dairy extension services were funded directly by the NZDB.

The question remains, how can uncertainty in the theatre of innovation be managed by those actors and organisations who form part of a theatre of innovation? The response to this question is organised in two parts. First in section 3.1, the notion of technology as practice is developed as a means of treating the material, social and cognitive dimensions of technology as a unity, and furthermore investing in technology management the capacity to interplay as practices. Second, in section 3.2, to discuss the implications of the practice perspective for organisations which have a vested interest in the harmony of the theatre of innovation. Section 4.0 seeks a response to the question, ' how can organisations manage **in** a theatre of innovation to fulfill their purpose, and contribute to the harmony of a theatre of innovation within which they operate? In the following section the relationship between strategy and uncertainty is developed.

2.2 Strategy as a response to uncertainty

What is strategy? Moore (1992), in his review of writers on strategy, considered Mintzberg to have gone further than most in terms of defining what is meant by the term strategy. To Mintzberg (1988) no single definition is adequate. He proposed strategy be defined in five ways, each being interrelated.

1. **Plan** - a consciously intended course of action which may be documented.
2. **Ploy** - or actions to outwit an opponent, are often expressed as threats rather than fulfillment of plans.
3. **Pattern** - a consistency in actions recognised after the event, though not necessarily intended by the actor or organisation.
4. **Position** - strategy is a way of defining the relationship between the actor, and the environment, *'the mediating force - or "match" - between organisation and environment'.*
5. **Perspective** - strategy is a concept, it exists in the collective mind of the organisation.

Each definition may substitute or complement the others depending on the strategic context. Strategy is context specific, as indicated in point 4 above, but can be either deliberate or emergent action (Mintzberg, 1994). Points 1 and 5 emphasize deliberate strategic activities, whereas points 2 through 4 are strong on the emergent properties of strategy. Strategy is therefore a processing of possibilities within the social and biophyiscal limits of action. Processing is itself an activity, though not to be confused with foresight. The latter refers to a prevalent misconception of strategy.

> *'Foresight is to the future what rain dances are to the weather, a belief in untestable causality. The assumption that a rain dance, properly exercised, is a necessary and sufficient cause to produce rain is impossible to disprove even though the rain may fall on many occasions without rhythmic stimulation. For every time the rain fails to fall one can always argue (reason) that the dance was performed improperly. When there are an infinite number of ways to malperform a rain dance and only one correct performance, statistically speaking the sound money bets on continued drought.'* [McDermott, 1996, p.192]

Strategy, as possibility processing may involve the use of methods to close down options for an opponent, or to vigilantly scan for opportunities, sometimes with a partner. Both scenarios are depicted in the use of the theatre metaphor.

2.3 Strategy and practice

Throughout the case studies the term *Muddling Through* was used to describe the way actors worked through the uncertainties of their situation. Muddling through does not imply clumsiness on the part of the actor in responding to challenges or capturing opportunities. The actors in the case studies were muddling in that they had no explicit rules that enabled a systematic closing down of opponents options, nor a systematic expansion of their own opportunities. Weick's (1995) notion of the organisation as a loosely coupled system asserts the presence of uncertainty, in terms of events and actor relations, that are expressed in terms of an ambiguity of interaction. This ambiguity increases with complexity in the problem domain. Weick advocates taking action as a first step in working out of strategy that involves some form of selection and retention of rules for instructing subsequent activity. However rules are never adequate in complex situations, actors confront a continuous stream of uncertain events that requires communicative cycles of adjustment by actors in response to the outcomes of their prior actions. Muddling through is a sequence of readjusting actions that build towards a recognisable pattern of activity, or method of accommodating uncertainty with more success than would be possible if the rules of adjustment were absent. Strategic activities by actors in the theatre of innovation attempt to eliminate errors in practice. Weick's notion of strategy as incremental adjustment under conditions of uncertainty is consistent with the experiences of actors in the case studies.

The point of departure between the Interplay Model and Weick is in the use of metaphor in a strategic application, or more the type of metaphor that Weick uses (the body). A biological metaphor implies a determinism that belies Weick's central thesis that uncertainty is the norm, and not determinism. The theatre metaphor

accomplishes the innovation and vitality implied in the biological model, without succumbing to deterministic restrictions of the body metaphor.

But is it strategy that links the practices in the theatre of innovation with managing in a theatre of innovation? From the case studies it was in the combination of strategy with integrity that all the aspects of practice found relevance for managing in the theatre of innovation. Strategy combined aspects of performance, but integrity ensured that strategy was used consistently with the norms of practice (competence). It was the use of rules that provided a unity of competent performance. Integrity was not alluded to in Gremmen's discussion of a practice (see Chapter 2). His depiction of a practice in Figure 2.2 will now be revised to incorporate integrity towards the attainment of harmony in a theatre of innovation.

In Figure 7.1 a distinction is made between an analytical level of practice, and a concrete level of actors and material objects. To attain harmony in a theatre of innovation requires the development of methodologies that operate at the interface where practices interplay. These methodologies need to account for the properties of practice. Methodologies for the interplay of practices are discussed further in section 3.2. The AKS perspective adopts a knowledge stance on the design of methodologies for the construction of programmes and organisational arrangements towards harmony in theatres of innovation. However, the case studies have identified the importance of analysing the activities of actors in the investigation of harmony. Thus the conflict between a practice and an AKS perspective centres on the analysis of actors and their activities.

The AKS perspective adopts the Habermasian approach of distinguishing between instrumental, strategic and communicative rationalities. As previously discussed, the practice position has these three rationalities operating simultaneously in any activity. The penalty schemes operated by the dairy companies in the SAMM case combined instrumental (BMSCC monitoring procedures), strategic (economic drivers) and communicative (feedback of results to farmers, and refinement of scheme using farmer feedback) as a unified scheme to lower the SCC of raw milk (outcome of activity) supplied by their farmers. Rationality (or knowledge) does not precede action in a practice perspective, but as Weick explains, an actor's knowledge of events or objects emerges out of his/her activities in those events, or use of those objects.

As an object, a practice is a way of doing. Practice as an analytical perspective conceptualises the organisation and sequencing of activities as competent (way) performance (doing). A practice perspective distinguishes between the types of rules that operate in a practice. Rules of the game, or defining rules, specify the aspects of performance:
the material (choice of antibiotic);
the cognitive (modeling antibiotic mode of action on pathogen);
and the social (the use of the veterinarian to administer the drug).

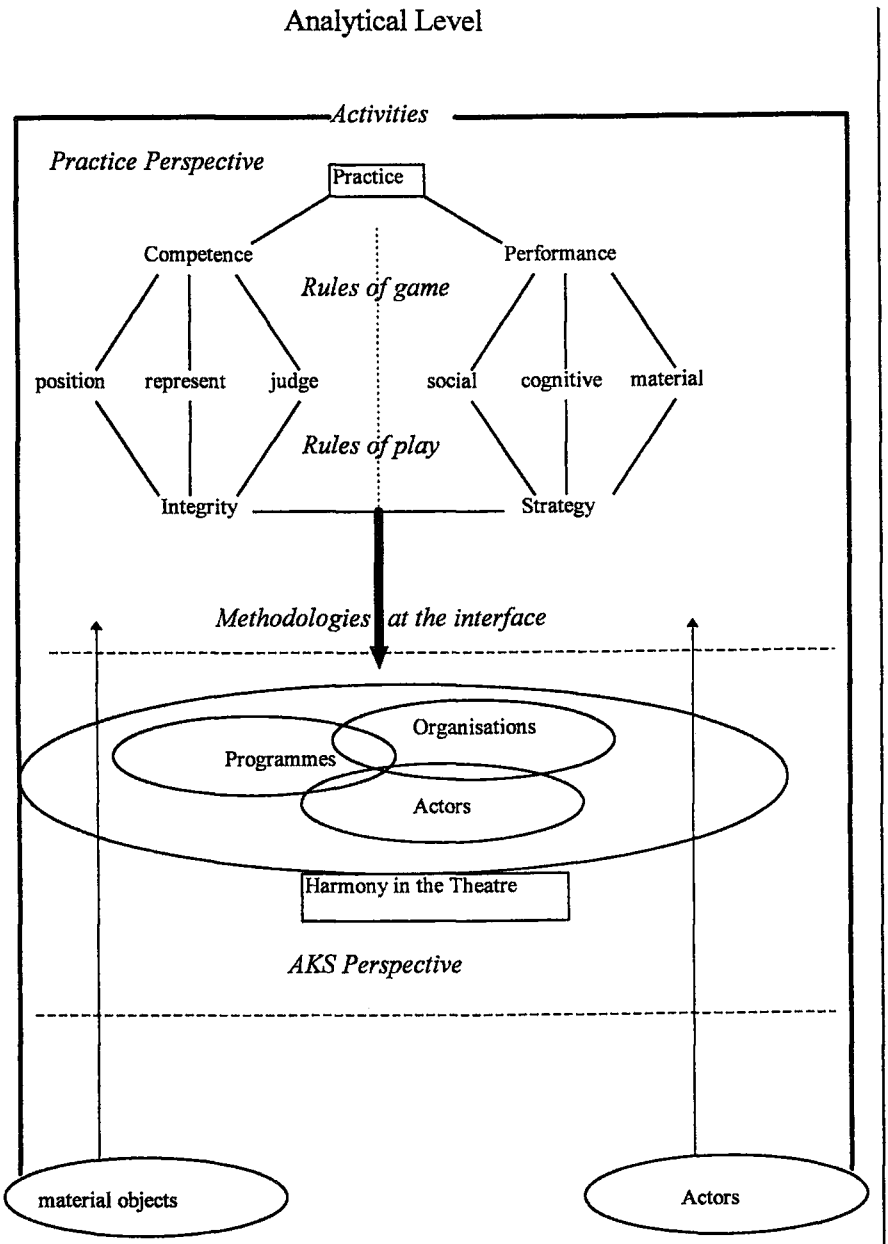

Figure 7.1 Revising Practice Perspective For Managing Towards Harmony in Theatres of Innovation

Rules of play, or experience rules, combine these aspects of performance in a sequence of activities. Each actor will combine and sequence their activities towards solving their problem of mastitis. The way actors combine the aspects of performance and sequence their activities over time expresses their strategic activity. The rules of the game open the possibilities, whereas the rules of play process these possibilities in strategic activity. Using antibiotics in DCT involved the combination of rules of the game and rules of play as a muddling through towards reducing the risk of contaminating milk with antibiotics while reducing the BMSCC of the national herd.

Rules also direct the working out of competence in the performance. Competence is difficult to access empirically. Performance is readily observed in activities, but what connects the dairy reproductive physiologist in NZ with the reproductive physiologist in the USA? Aside from the tangible connections of email and publications, these practitioners use rules of the game to:
position (USA physiologist accesses large laboratory resources,; NZ physiologist accesses large systems resources);
represent (USA physiologist is an expert on follicular waves; NZ physiologist is an expert on problems of anoestrus cows);
and judge (NZ and USA physiologists work on similar problems).

The rules of the game specify aspects of competence, but it is the rules of play that combine these rules as integrity. It is in the elusive realm of competence that integrity is most influential. A unity of practice is formed by the way integrity is worked out in strategic performances through the rules of play. The farmers in the SSGP positioned themselves as speakers in the field day to represent their work to other farmers because they judged it significant to NZ dairy farming, they performed this activity by using soil profiles, maps and tables to convey a message in a way that appealed to the farming folk in their community. Gremmen (1993) considered the rules as only an aspect of competence. The case study investigations have, however, identified another level of practice, a level of rules that work to combine aspects of competence and aspects of performance in a unity of practice.

There remains the issue of interplaying practices. If the above revision of the practice concept is to have relevance to those with an interest in improving harmony in a theatre of innovation, it needs to contribute towards improving the way practices interplay to span actor, programme and organisational boundaries. Gremmen (1993) depicted the interplay of practices as an event occurring at an interface shared by practices (see Figure 7.2).

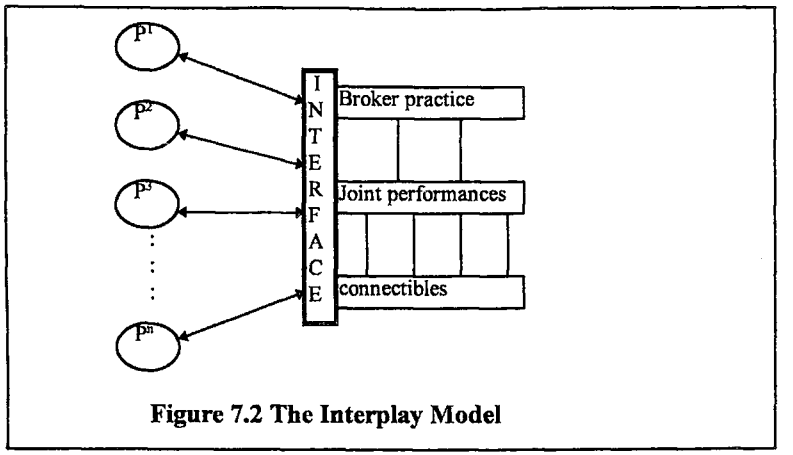

Figure 7.2 The Interplay Model

The Interplay Model distinguishes between classes of interplay. Many connectibles, like chance meetings at a conference, are involved in building towards a joint performance, which in turn may evolve into a broker practice. A broker practice combines aspects of competent performance from many practices into a unique competent performance. In terms of harmony in the theatre of innovation, the model suggests sufficient connectibles ought to operate to ensure joint performances, and that broker practices emerge as and when required. In so saying, the model depends on the way rules are used to align with those situations demanding joint performances or broker practices. How have the case studies contributed towards an improved understanding of these conditions and rules?

Findings from the case studies relate to an improved understanding of the relationship between interfaces for interplaying practices and harmony in the theatre of innovation. Contributions to the Interplay Model are organised under five sub-headings.

Interface conditions

Practices are arrangements of activities that interplay in such a way that problem definitions are continuously refined for the performance of strategic action. In the case of CIDR it was the problem of controlled release that first intrigued actors and fostered an interplay of practices. The issue of problems for practices is developed further below. However, problems are not interfaces for the interplay of practices. Problems provide the conditions for fostering interplays at the interface.

A second interface issue arising in the case studies relates to the aspects of performance discussed above. Connections between practices emerged around the sharing of objects like conductivity meters (SAMM), or collective learning about nitrogen (SSGP), or the formation and use of clubs (CIDR). Practices shared these aspects of performance and sometimes shared strategy by muddling towards desired outcomes in a problem domain like lowering SSC, or compressing calving patterns, or managing natural resources through farming. The sharing of aspects of performance is developed further under the sub-heading 'Interdependence' below.

Finally, mediating practices emerged as a type of second order competent performance. The activities of the NMAC sought to align the various practices necessary to reduce SCC in raw milk. The SSGP developed rules for working together, and rules for working on the substantive concern - resource management in farming. The primary concern of the mediating practice is the interplay of practices at the interface, and ultimately, harmony in the theatre of innovation to ensure appropriate practice interplays are performed. Mediating practice is discussed further under a separate sub-heading below.

Problem domain

Defining a problem of sufficient concern such that all actors chose to mobilise activities towards performing a shared practice was a recurring feature in the case studies. Problem definition was an iterative process in SAMM. Similarly, the SSGP had to revisit its overall purpose to ensure resource management advocacy was not lost from the group. The CIDR case evidenced an expanding definition of the problem, from developing a device to the alignment of several practices to develop control breeding technologies. Expansion of definition raises the issue of problem domain.

The problem domain of action is particularly concerned with the fit between the components of the theatre of innovation (programmes, organisations and actors), and the interface for interplaying practices. To the question, does a practice have a purpose, the answer is yes, in as much as a practice is what actors organise to respond to problems. When the programme, operating as an interface, does not effectively align with the problem domain, harmony in the theatre of innovation will be undermined. It took considerable effort on the part of the SSGP leaders to work through the themes and topics necessary to gain an alignment among the actors in the programme. Without this effort, the interplay of practices would likely have been impaired. Actors and organisations gain a legitimacy of involvement in programmes because they offer the programme access to practices that have a high chance of contributing relief from the problems confronting that programme. The mediating practice is particularly concerned with improving the definition and specification of problem domains (see below).

Interdependence of practices

Actors and organisations are interdependent when they require access to one anothers' practices to competently perform their own practices and resolve their problems. The actors working to develop monitoring services in SAMM were dependent on a systematic documentation (the Yellow Book) that stipulated the feasibility of the programme to counter doubts by colleagues. The developer of the CIDR depended on polymer engineers to have developed a substrate with appropriate release characteristics. In both these examples the dependency could be described as one way, either object or cognitive aspects of practice, provided by one practice to serve the needs of another. However nutrient balance work in the SSGP was interdependent as researchers, professionals and farmers all worked towards developing monitoring and modeling tools that refined the application of nitrogen on pastures.

The working out of interdependent aspects of performance in a practice is iterative and incremental. The joint purchase and management of the research herd, for further development of the synchronising technology, was neither necessary nor feasible in the case of CIDR, until the problem domain was adequately framed and the rules of synchronising, and **interplay** between the practices was made sufficiently explicit for the establishment of the joint venture. At times the social aspects of performance can provoke errors in the practice of interplays, as with the delayed introduction of the veterinary practice to the CIDR development. The rules of interplay often have instrumental implications for practices, such as the allocation of responsibilities for risks and the decisions about who will benefit from programme successes.

Windows of Insight

This obscure phrase refers to the elusiveness of competence in practice. When actors worked to refine synchronisation systems they began to experience insight into other professions. This insight required a corresponding integrity of action on the part of the actors to sustain trust and in some situations extend shared performance. Competence is elusive and will likely remain the philosopher's domain of inquiry. However the integrity of practice, particularly when performing in professional practice, is accessible to the social researcher. The integrity of farming was increasingly appreciated by resource management advocates and researchers alike as they worked together on farms, while not compromising their concerns for resource management issues in the SSGP. Research was repositioned to align with farming needs, as in the rebuilding of nutrient balance models. Farming was represented to others as a resource management practice by farmers. Actors acquired critical debating skills to boldly, but sensitively judge one another and construct monitoring methods that had a high chance of assisting resource management through farming. As practice integrity grows among the actors the uncertainty in the theatre of innovation diminishes, harmony emerges and practices interplay towards more effective resolution of shared problems. Integrity combines the unity of the actor (or security in professional conduct) with unity of the community (or professional cohesion), integrity is an integration of value systems.

Mediating Practice

The performance of interplays among practices is a practice in itself - a mediating practice. A mediating practice operates **on** the interface. The SAMM was the interface for the interplay of practices concerned with the improving mastitis management, but the NMAC was an interface for the mediating practice to operate on the SAMM. Mediating practices perform by integrating issues of problem domain, practice interdependence and insight to improve interface conditions and foster harmony in the theatre of innovation (see Figure 7.3).

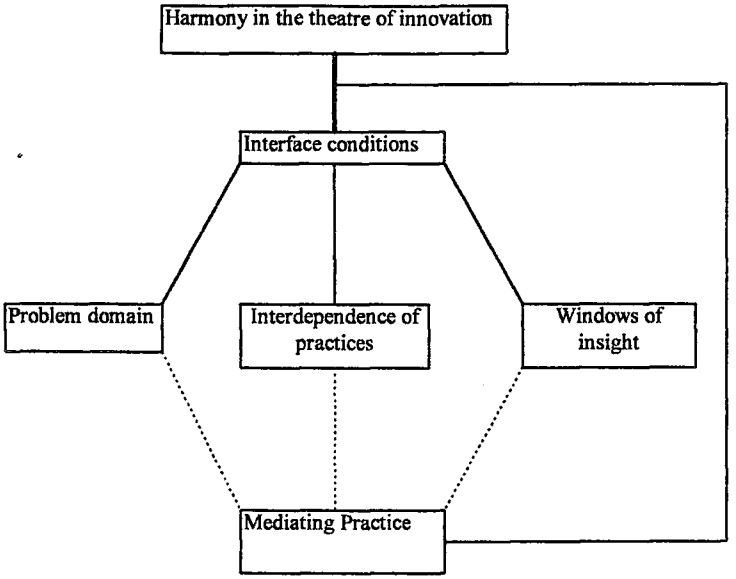

Figure 7.3 Interface issues of significance to harmony in the theatre of innovation

How does a mediating practice perform? Discussion of the problem domain indicated the mediating practice works to improve the definition and scope of problems that require the employment of practices. The working out of themes through a combination of belief mapping and brainstorming in the SSGP was a way of mediating the problem domain among practices. The RAAKS methodology is a particularly powerful toolkit for accessing and developing problem definitions and ensuring these definitions have adequate scope to accommodate all the actors in the theatre of innovation (Engel, 1995). The power of RAAKS lies in its use of multiple perspectives on the problem, these perspectives being generated by multiple actors working in a team situation. However a risk of using RAAKS is that actors may not be included as RAAKS analysts, the latter being a 'team' that enters the problem domain, analyses the situation and then reports to actors their findings. A more fundamental modification is to focus on the activities of actors, rather than the actors themselves. Some modification of RAAKS that enabled actors to access the RAAKS toolkit as and when required in the emergence of practice would extend the power and relevance of RAAKS as a mediating practice methodology.

A second mediating practice performance relates to the way of enlisting actors new to the interface. Enlisting actors can be on a temporary or permanent basis. A temporary enlistment of a research worker from the USA enabled the NMAC to resolve disputes within the committee that were stalling progress on reducing SCC in the national herd. This temporary enlistment contrasted with a permanent enlistment of actors who resourced or empowered the NMAC, such as milk quality managers

from dairy companies. Enlistment requires a mediating practice to adequately define the problem domain for attracting the commitment of actors to work at the interface.

The third mediating performance observed in the case studies involved the building of rules for working together. Mediating practice in the SSGP defined rules for give and take, as in the visit of the Missouri researchers. This visit also demonstrated rules of mediating communication. Other communicative issues related to extending the message of the group through active means like the use of theatre performances. Furthermore, the rules of critical debate were refined over time as the SSGP members worked out their resource management in farming. Critical debating required an emerging integrity among actors that enabled the constructive use of judgments about nutrient balance problems.

This completes a revision of practice and the Interplay Model using the case study findings. It remains to apply this revised perspective to the issues of the NZ dairy theatre of innovation. As discussed in section 2.1, a two stage response will follow, first developing the notion of technology as practice, then using this notion to explore the strategic implications of the Interplay Model for organisations in the theatre of innovation.

3.0 The development of technology as practice in theatres of innovation

3.1 Practice and theatres of innovation

Why refer to technology as a practice? The practice perspective of technology accounts for what actors do in a theatre of innovation, how they perform in terms of harmony or disarray in the theatre of innovation. This account of technology as a way of doing helps explain why organisational barriers can be bridged, and professional rivalries stalled to permit the combining of aspects of performance towards resolving a common problem. Technology as practice considers the content of discourses in a social and material context that is defined by the problem domain of the actors. It is what actors do that counts in harmony, the coordination of beliefs operating in the cognitive realm emerges from the context.

Hård (1994) referred to technology as practice in his analysis of the Cummins diesel. He argued against technological closure, whereby the solving of fundamental problems of a technology results in a global stabilisation and stagnation. Instead he claimed that technology was an outcome of local network activities that followed a design path in a piecemeal fashion. Hård referred to *habitus* to frame his theoretical perspective, based on the work of Bourdieu (1990). Habitus refers to a set of acquired actions and associated concepts that link social structure and action.

> *'The theory of practice as practice insists, contrary to positivist materialism, that the objects of knowledge are constructed, not passively recorded, and, contrary to intellectualist idealism, that the principle of this construction is the system of structured, structuring dispositions, the* habitus, *which is constituted in practice and is always oriented towards practical functions.'* (Bourdieu, 1990, p.52).

Bourdieu's concerns are at the level of grand social theories, offering a cultural approach to linking structuralism with functionalism to explain social action. Hård used Bourdieu to interpret his analysis of the diesel as an embodiment of history and dispositions,

> *'We would highlight the* **contingent** *and* **pragmatic** *character of engineering, and would acknowledge the existence of intersubjective factors in technology, but we would not suggest that these elements are always globally known or accepted, nor that they are identically interpreted everywhere. We would treat engineering work as a social activity, a practice that includes both abstract and concrete elements, both* **universal knowledge** *and* **embodied skills.** ' (Hård, 1994, p.573).

How does Hård's use of Bourdieu arrive at technology as practice, in comparison with the Interplay Model? The two positions agree on many of the empirical issues relating to the analysis of performance. However, the perspectives diverge in terms of the use of rules and competence in practice. Hård leaves the interplaying of practices as a largely undeveloped area. With respect to rules, Hård argues rules only describe certain patterns in society, they do not govern peoples' behaviour. In this Hård is inconsistent for he claims, as quoted above, that work is performed using **universal knowledge**. The Interplay Model combines local knowledge (the cognitive aspect of performance) with universal knowledge (competent judgment) by the use of defining and experience rules.

A Bourdieuian conception of practice is therefore imperfectly adapted to addressing issues relating to the interplay of practices. For example, Hård regularly refers to a *common practice*, meaning the generally chosen solutions or generally applied methods of practice. An extending of a practice therefore depends on sufficient similarity between the contexts of several local practices for them to merge their solutions and methods. In contrast, the Interplay Model represents practice as extending by projecting its activities into other practices' domains of work, and by enlisting other practices into its domain of work. This extending is achieved by sharing aspects of performance that work through to a sharing of rules and ultimately integrity among practitioners. Solutions are ways of using rules that solve problems - the competence in the performance. The Interplay Model is therefore more explicit about the way practice is shared as an emergent continuum of connectibles, joint performances and broker practices. Furthermore, mediating practice can be defined in the context of Interplay, whereas it finds no place in Hård's perspective of technology as practice, where he describes a technology's design problems as problems within a practice - diesel engineering.

In the Interplay Model technology as practice refers to the way a technology embodies the rules of the game. The synchronising technology had practitioners performing according to the rules of the game because the technology is explicit in terms of materials, protocols and service support networks. A new competence was shared among actors as they played with the rules for their specific situation, such as washing and reinserting the CIDR device to improve cow synchronisation. A technology therefore assists actors to perform a practice by combining the aspects of performance according to the rules of the game, while not denying the actor innovative opportunities. A device provides access to a practice, the hardware being a convenient means of embodying many aspects of a practice. Actors can still

experiment, model and monitor to construct new performance routines using the technology. The way actors go about constructing new performances reveals competence in the performance. Veterinarians were positioned to provide synchronising services, and developed a collective appreciation of errors in synchronising practice. This ability to judge errors in practice did not depend on physical proximity in the way that collective performance requires proximity to access hardware.

The Interplay Model provides cautions as to how the technology as practice concept is used in the theatre of innovation. The formation of clubs of actors can promote technological closure with a consequent stagnation of innovation. It was the interplaying of practices in the CIDR and SAMM case studies that prevented technological closure and provoked reflective actions in response to demands from outside the practice. A second concern with technology as practice is the possibility of the technology embodying errors of practice. In viewing technology as practice the technology becomes an extension of the actor, fostering new repertoires and amplifying the actor's capacity to act in the problem domain. In this context the technology becomes part of the actor. A convergence of practice and actor through technology may mean errors of practice embodied in a technology will be retained and sometimes defended by the actor. Again the interplays of practices that provoke reflective activity will often counter the perpetuation of errors in practice. Clients and mediating practice performances may also provoke reflection on action towards the elimination of errors in practice.

3.2 Mediating Practice and harmony in theatres of innovation

The mediating practice was discussed at some length in 2.2 above. This discussion centres on the performance of mediating practice in the theatre of innovation. Similar to the discussion on technology as practice, this section opens by comparing the Interplay Model perspective of mediating practice with an alternative contemporary perspective.

Mediation has emerged in recent years as one of several third party interventions for resolving conflict among individuals or groups, be they organisations, communities or nations (Pruitt and Carnevale, 1993). In a comprehensive discussion of contemporary mediation, Bush and Folger (1994) advocate a transformational mediating practice. The way the authors' report on the pedigree of transformational mediation is in itself consistent with the practice perspective.

> *'The Transformation Story of the mediation movement is not widely told in the published literature of the field. The few who expound it include practitioners ... and academics ..... . Nevertheless, beyond the world of the printed word, this story is given voice in informal discussions among both academics and mediation practitioners. It is, as it were, the underground story of the movement, often the motivating force behind practitioners' involvement. Perhaps it goes unstated because it is not easy to articulate, or perhaps people are hesitant to articulate (or enact) it for fear of seeming too idealistic and impractical.'* (ibid., p21.)

The term story is used with respect to an historical emergence of the practice. Transformation mediation refers to a way of transforming disputing individuals and society as a whole through self-determined problem definition and problem resolution through action. A transformation practice works on the patterns of transformative actions performed by disputing actors.

> *'Thus the three primary patterns of transformative mediation - microfocusing on parties' moves, encouraging deliberation and choice making, and fostering perspective taking - are plainly evident in this session [refers to a Landlord - Tenant case]. Also apparent is the way that these patterns can combine in dynamic interaction to produce other, more subtle contours of transformative practice.'* (ibid. p.197)

The *more subtle contours* refer to the empowerment and recognition (an identity effect) produced in the disputing actors that mediating actors can use in a sequence of transformative moves that work towards accomplishing commitments among the actors. Actors identify typical events as signposts for employing particular mediator activities.

Bush and Folger compared their transformative practice with other forms of mediation in several dimensions (see Box 7.1). Their primary basis for distinguishing between mediating practices was based on referring to the underlying values of the practice. Using this schema they identified a problem-solving practice inspired by a goal of utilitarian satisfaction for the individual, and a participatory practice inspired by a collectivist value for harmony that has the needs of the individual subject to the demands of the group. The authors suggest problem-solving mediation characterises western societies, whereas participatory practice is typically performed in developing countries. The contention is that transformative practice subsumes participatory and problem-solving practice because of the underlying value system of transformation is an overarching value system of the disputing actors' worldviews.

> *'If the ultimate value is transformation, the qualities of the human being that seem central are the ones necessary to achieve this end, to act with compassionate strength. These qualities include all the features seen as central by both of the other two worldviews just described - plus the ability to integrate them into a balanced whole. If compassionate strength is possible in human conduct, as the transformation value assumes, human beings must be seen as capable of both strength of self and concern for others.'* (ibid. p.242)

Box 7.1 Values and Worldviews of Mediating Practice

Value	Satisfaction	Harmony	Transformation
Worldview	Individualist	Organic	Relational
Orientation to conflict	Problem-solving	Individual subject to group	Transformative
Historical origins	Satisfaction	Collective identity	Transformation
Approach to practice	Problem-solving	Participatory	Transformative

(Source: Bush and Folger, 1994)

How does the transformative mediating practice compare with the mediating practice in the Interplay Model? Bush and Folger treat practice as an object, transformative practice is a way of doing mediation. Their analyses of transformative practice builds from a method, referring to *rules of the game* to connect with aspects of competence using cognitive descriptors like *values* and *worldview*. Transformative practice is a method of conflict resolution using third party intervention. Mediating practice in the Interplay Model does not necessarily require third party intervention. Nor does the Model assume the presence of conflict as an initial condition for the practice of mediation. On the contrary, mediating practice is a permanent feature of interplay practices, being that practice that operates whatever the nature of the problem. Problems of ignorance, errors in practice, or uncaptured possibilities may all inspire the performance of mediating practice. Finally, and most significantly, Bush and Folger use an obviated view of harmony to compare transformative practice with its rivals. They are close to inane in their treatment of both individualistic and collective action, thereby enabling subsequently claims about the subsuming powers of transformative practice over the former. By contrast, the treatment of harmony in the theatre of innovation connects the actualisation of actors and organisations as an outcome of integrity in practice. The theatre metaphor (see Figure 7.4) is again useful as a means of illustrating the way harmony in the theatre of innovation fulfils both individual and collective action with respect to innovative activity (Engel, 1995).

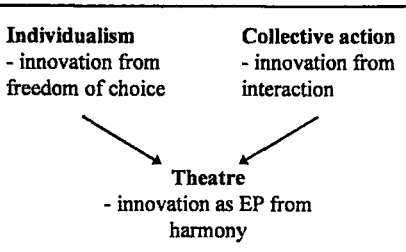

Figure 7.4 Innovation as emergent property from harmony in the theatre of innovation

Transformative practice is therefore a third party intervention in conflict situations, many aspects of which have been previously described in the organisation theory literature as change management.[1] Mediating practice in the Interplay Model refers to a practice working on interplaying practices. Mediating practice may use what Bush and Folger define as transformative, participatory or problem solving *practices* as ways of doing interplay, though this requires further qualification of the mediating actor. The mediating actor in the Interplay Model can *with integrity* represent the diverse practices at interplay in the interface. Such actors are rare and often undervalued in organisational settings, as identified by Gibson and Rogers (1994). Mediating practice is often performed implicitly by actors in practice interplay

[1] see for example McLennan, R. 1989. Managing Organisational Change. Prentice Hall, Englewood Cliffs, N.J.

situations. The role of third party mediating actors can be easily discredited when resources are scarce, with a consequent risk of heightening disharmony in the theatre of innovation. Conflict is a likely but by no means only outcome of this disharmony. Economists may well identify increased transaction costs emerging in a theatre of innovation as an outcome of indigenous rationalisation towards mediocrity, not as an outcome of conflict, following the removal of a third party mediating practice like MAF advisory services. Conversely, clients may well replace the need for the third party mediation in the theatre of innovation, and perhaps lower transaction costs through the operation of efficient market signals influencing the interplay of practices. Professional practices will however attempt to *tame* clients, whereby the client is taught to comply with the rules of the practice. In some situations it may not be enough to rely on the client to stimulate the requisite innovative change for a sector wide competitive strategy. In this context the NZ dairy sector continues to fund an independent consultancy service that primarily mediates as a third party between farming, sector policy and research. Mediating practice as a third party in the theatre of innovation requires more than the symbolic interactions involved in the exchange of knowledge and information among actors. Introducing new synchronising technology was performed by several professions combining aspects of practice on farm.

Mediating practice is not a rationalisation by intention, a grasping forward as condoned by the AKS perspective. Rationalisation emerges out of activities, a mediating practice follows the pattern of muddling through, with a mediating actor provoking a reflection on action towards the building of collective activities at the interface. The mediating actor does not consider foresight a faculty of strategy, but rather:

> *'The foresight we need is an awareness that our theories of society and human behaviour are strategically flawed, incomplete, even counter-productive at times. In the end, as in the beginning, we can only speak about some of the reasons we cannot possess the foresight we seek and paradoxically how disastrous, surprising and unsatisfying it would be if we could, given how our minds currently work. The real foresight problem is how to live without what we imagine we need.'* [McDermott, 1996, P.194]

This raises normative issues for mediating practice. Does a mediating practice condone some forms of interplay and not others? In as much as errors of interplay are possible, a mediating practice will judge between correct and incorrect interplay. The experience of the SSGP progressed through stages from the making of many interplay errors like leadership presumptions about purpose, production issues dominating problem definition and confusion about farm information, to the building of integrity with resource management and production issues interwoven in broker practice. What might the integrity of mediating practice entail? The Bush and Folger reference to *compassionate strength* described an integrity for a mediating practice applied in conflict situations. Of more importance than point in time statements that allude to the integrity of a mediating practice is the dynamic of integrity. Solomon (1992) has indicated that integrity evolves in practice. Furthermore, although actors in a theatre of innovation do not usually refer to a mediating practice, the mediating practice performs for the harmony of the entire theatre of innovation - a business analogy illustrates the point:

> *"Insofar as the purpose of business is to provide for the prosperity of the entire society, one might say that there are no mere spectators and the purpose of the practice is to provide for those who know very little about the practice or even that it exists."* (Solomon, 1992, p. 122)

A mediating practice discerns when interplay is violated by corrupt, destructive or degrading activities, seeking instead to replace destructive with creative interplays that are universally attractive to the interplaying practices. A mediating practice performs by serving the integrity of the interplaying practices, not as a mechanistic interplay routine. When third party mediation is performed, the identity of the mediating practitioner is not dependent on a continuous involvement at the interface. Rather, the mediator derives identity through mediating practice, where the interplaying practices are an aspect of mediating performance, and the sequencing of mediating actions are judged according to the rules of mediating practice. This does not imply all mediating actors are third party actors. An actor can perform dual substantive and mediating performances at the interface, though this is more demanding in terms of identity and integrity.

Methodology has been a recurring topic in the above discussion. What are the methods of a mediating practice? This question requires a response at the level of practice, and in relation to the development of methodology to support practice (see Figure 7.5).

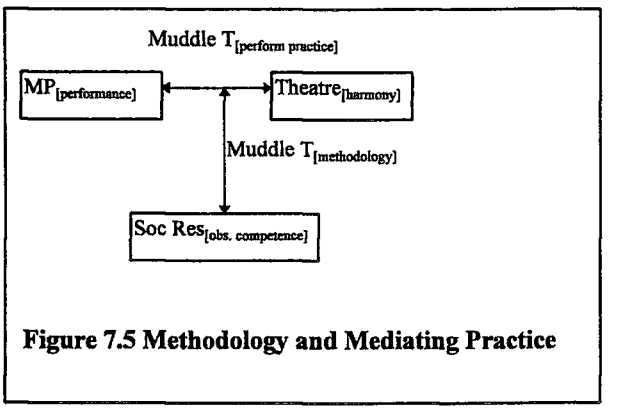

Figure 7.5 Methodology and Mediating Practice

Methodology for Mediating Practice

As discussed above, the RAAKS methodology offers an opportunity for actors to capture multiple perspectives on problem domains, and through time rapidly focus down onto core issues that span all practices interplaying at the interface. The RAAKS *toolkit* is open-ended enabling actors to build customised routines for specific interface situations.

Transformative Mediation is a second methodology for the practice of mediation. The methodology is restricted to third party interventions in conflict situations. However, it represents a highly developed form of mediating methodology for use in third party situations.

A third methodology has recently been developed by Gremmen *et. al.* (1997). In approaching the problem of *Making New Nature* in The Netherlands the team developed a methodology to clarify the multiple interests in the use of Dutch landscapes. By interviewing actors and separating defining rules from experience rules embodied in their responses it was possible to distinguish interfaces and strategies and observe the convergence of interfaces over time (see Figure 7.6). This methodology enabled the arrangement of actor positions in a matrix that could then be used to design interventions to position and negotiate with actors in relation to issues associated with the *Making of New Nature.*

		Purpose (Defining rules)	
		Abiotic (input based) [processes that underpin nature, eg. Soil: water: climate etc.]	**Biotic** (output based) [components of nature, flora and fauna etc., population dynamics and species interactions]
Spatial Strategies (experience rules)	**Separation function** [isolate landscape and eliminate human intervention]	Interface = WWF Strategy = *big & wild*	Interface = Nature Heritage Strategy = *diverse & rare*
	Interwoven function [integrate landscape with human activity systems]	Interface = ANWB (syn: AA) Strategy = *robust nature* [recreation in nature]	Interface = Farmers Union Strategy = *conservation agriculture*

Figure 7.6 A Matrix for Position Actors in New Nature Programme

The team in the Making New Nature programme observed an interface convergence through harmonization of experience rules, whereby the WWF and ANWB converged, as did the NatureTrust and Farmer Union. This suggested the experience rules were more malleable in negotiative situations than defining rules.

Mediating actors may also use many of the participatory methodologies discussed in the FSR literature (Okali *et.al.* 1994; Pretty, 1995). The critical feature in all these methodologies is that they enable the analysis of activities as *ways of doing* mediation towards improved harmony in the theatre of innovation.

Methodology for Supporting Mediating Practice

This second class of methodologies seeks to inform mediating actors in their work. An example of these methodologies is action research, as in the SSGP case study where grounded theory and the NUDIST software were combined in a general action research strategy.

Another example of these methodologies again uses an action research strategy and involves the actors in data collection and management activities through the use of practitioner logs (Beijaard, 1990). These logs are specialised diaries that are useful both to the actors in their work routines, and to the analyst for observing what actors do in their work. This methodology has been used in the study of agricultural educators to build new learning strategies by referring to what educators actually do during teacher : student interactions.

Other methodologies that may contribute to supporting mediating actors include the development of object based dialogues that use a combination of laboratory and fieldbased studies (Cremers, 1996; Tucker and Dempsey, 1991). Dialogues may be verbal and non-verbal in the building of collective activities around the development of new technologies.

More abstract methodologies pertain to the use of modeling work for informing mediating actors. Recent developments in Cellular Automata and the construction of genetic algorithms suggest decision rules can be generated, and by inference related to the activities of actors in a theatre of innovation (Mitchell *et. al.* 1993; Rajarshi *et. al.*, 1995).

The development and integration of methodologies that are capable of informing mediating actors in their work is at a rudimentary stage of development. However a common feature of the methodologies either used or suggested for use in the analysis of mediating practice is that they are capable of appreciating change in the aspects of mediation, and in identifying rules for mediating.

This concludes the analysis of mediating practice in relation to harmony in the theatre of innovation. It remains to discuss the practical implications of technology as practice for the programmes and organisations operating in the NZ dairy theatre of innovation.

4.0 Implications for managing in the theatre of innovation

The reforms in the NZ economy were designed to improve the interplays among practices operating in the theatre of innovation. What are the implications of this study with respect to the impact of reforms on the dairy sector? In particular, what recommendations can be made to the organisations and programmes that currently operate in the sector?

This study investigated opportunities for improving harmony in the theatre of innovation by using a practice perspective to identify development of possibilities, embodied as new technology. This study did not set out to evaluate policy reforms. Section 3.0 formulated a response to the question of how linkage activities evolve technology for the dairy sector. This section will respond to the second problem statement, viz., how can an understanding of linkage activities inform technology managers in the dairy theatre of innovation? The response is in two parts. A descriptive summary outlines a perspective on organisations working together to

evolve technology. This description is followed by recommendations for specifying the conditions that operate at the interface of practices, both at an organisational and programme level.

4.1 Descriptive Summary

In a free market, '*actions speak louder than words*'. Resources for programmes are allocated to generate outcomes that are consistent with the needs of members in a market channel, or to satisfy policies for prudent management of natural and cultural resources. One of the challenges for new R&D companies, that have emerged following the economic reforms in NZ, is to position the organisation in relation to the activities in the market channel of the sectors they serve. This positioning requires sensitivity on the part of the R&D companies, whereby the activities of existing channel members are enhanced through working relationships with researchers, who themselves retain their integrity as researchers. These R&D companies are viewed in this study as loosely coupled systems of practices. It is the way the practitioners perform a practice in an organisation that positions that organisation in relation to the members of the market channel it serves. In the dairy sector the new R&D companies like AgResearch and DRC have practices that have operated for some time in the dairy theatre of innovation. These practices represent an opportunity for the R&D companies to build on a practice track record while claiming a new organisational function for the sector. Organisations represent an interface where a continuity of change in practices can be worked out through interplays.

Viewing organisations as interfaces for the interplay of practices reformulates the place of technology in the sectors. By referring to **technology as practice** the place of the new R&D companies in the sectors is made clear - these companies provide the sectors with new ways of doing their work - new possibilities for performance. Technology is a way for the R&D companies, and others in the theatre of innovation, to package practice. The new R&D companies find their place in relation to market channels and natural resource policies by offering new practice possibilities. These practice possibilities cannot be formulated in isolation of the practices operating in the sectors. Interplays of practices are required which do not reside within any one organisation - new interfaces are required. These interfaces are provided in the form of programmes, whereby practices operate on problems of mutual interest to the actors and sector organisations. Programmes are specialised interfaces that enable practices to operate outside organisational conventions. Programmes are used in sector market channels as interfaces to enable organisations to work together to evolve technologies that contribute towards improving sector-wide competitive performance.

Practices interplay when they have common substantive concerns, though different ways of operating on problems. However the way practices interplay does itself constitute a type of practice - a mediating practice. It is the mediating practice in programmes that works to improve interplay performance. A mediating practice is likened to the directorship of a theatre production. The descriptive power of the theatre metaphor however goes beyond directorship to include the activities of each and every actor on the stage. Mediating practice is expressed in the performances by

each actor, performing in relation to the other actors. Similarly, in a market channel or a resource management domain, a mediating practice is performed by actors who are building a shared practice to operate on common problems or opportunities. At times a third party mediation is involved. The reforms in NZ devolved the third party mediating capability performed by government extension officers for farming. A perhaps implicit assumption in this devolution was that mediating practice is performed adequately, or even more effectively, as an invisible hand operating among financial, legal, agribusiness and technical professions for farming. The dairy sector however retained a third party mediating practice - a sector-wide consulting officer service to farming. Regardless of a third party performance, a mediating practice works to foster integrity. The integrity of practice emerges from the work of extending a practice. To extend a practice requires a positioning and representation of practice in a theatre of innovation. The mediating practitioner continually strives for more realistic portrayals of the practice to others. It is through a mediating practice that the work of an organisation or programme (interface) is represented with integrity, which in turn lowers uncertainty in the theatre of innovation.

4.2 Conditions at the interface

Recommendations for the management of the interface conditions relate to organisational and programme issues.

For organisations

Organisations ought to clarify their function with respect to the market channel. New R&D companies need to represent their functions and responsibilities in relation to market channels in terms of practices performed to capture opportunities or resolve problems. Representing organisations as loosely coupled systems of practices is difficult for administrative managers of R&D companies. The ambiguity of representations ought not to be viewed negatively, but rather captured as an opportunity to *manage by paradox*. A paradox management performance by administrative managers would assist to clarify the relation of the organisation to the market channel, by clarifying the relation of practices one to the other at interplay. This is possible when administrative managers recognise their limitations in appreciating the competent performance of practice, yet cultivate competence in critically appraising the emergence of practices within the organisation.

The system concept is a useful concept for fostering critical appraisal that crosses divisional boundaries within organisations, and inter-organisational boundaries in sectors. Neither concepts, nor formal structures like revisions of organisation charts are sufficient in themselves to foster clarity of organisational position in relation to the market channel. It is the performance of joint work on shared problem domains that capacitates systems concepts and organisational reforms. New R&D companies need to identify problem domains in the market channel in which they can play a role. To identify these problem domains requires an evolution of concepts that complement the evolution of practices in organisations. Technology ought to be conceptualised as practice.

Aligned with the technology as practice concept is the use of the Interplay Model by organisations seeking to position themselves with respect to market channels in sectors. Administrative managers of organisations need to vigilantly appraise programme proposals in terms of what the proposal offers as interface possibilities for practice interplays. Programme management is a mediating practice activity. Managers in organisations need to appreciate the function of mediating practice, and guard against exerting excessive ownership over programmes that constrains the possibilities for new practices to enter programmes. Furthermore, mediating actors need explicit recognition in organisational structures, being those actors who embody the capability to appreciate the needs of the market channel, and the arrangement of practices for working on those needs. The mediating actor is not immune to paradox management. On the contrary, administrative managers ought to pay considerable attention to the performances of mediating actors with respect to the development of integrity. It is through the integrity of practices at interplay in the sector that transaction costs are likely to be lowered and uncertainty effectively managed towards a sustained competitive performance on world markets for dairy production. The issue of transaction costs and uncertainty raises the need for further research and monitoring of sector R&D management.

For programmes

Mediating actors often work in programmes where the interplay of practices is not supported by formal methodologies for managing the interface. Indeed, few methodologies are explicit about the attributes of practices and interplay performances. The development of methodologies for mediating actors as discussed in section 3.0 above is a critical task confronting the dairy sector. Arranging the programmes discussed as case studies in chapters four through six in a matrix as outlined by Gremmen *et.al.* (1997) distinguishes between defining and experience rules and type of interface and strategy characteristics (see Figure 7.7). Mediating actors could map existing and proposed programmes for the dairy sector in terms of experience and defining rules towards aligning strategies for harmony in the theatre of innovation. One modification or development to the matrix would involve the specification of a Strategy:Integrity category for each cell. Mediating actors could apply the matrix by designing new programmes (interfaces) to meet sector needs, and aligning programmes that share similar purposes (defining rules) but use different strategies for achieving outcomes.

The use of the matrix may inspire further methodological developments, towards improving the needs analysis of the market channel and for positioning practices to serve these needs.

Mediating practice is itself a domain of inquiry. The impact of the reforms in the NZ economy has radically altered the way mediation is performed in some sectors. This study has concentrated on the dairy sector, a sector that retained its consulting officer services and remained vertically integrated over the period of the reforms. Further analysis could compare the diverse forms of mediating practice in relation to various sector arrangements. This analysis could include the comparison of transaction costs with respect to the use of technology for competitive performance. Such an analysis

would in turn require some clarification about the types of mediating practice observed in different sectors.

		Purpose (Defining rules)	
		Support supply chain (input based)	**Produce finest quality milk** (output based)
Technology Strategies (experience rules)	**Component revolution**	Interface = CIDR Strategy = *control release using natural substances*	Interface = Strategy =
	Incremental adaptation	Interface = SAMM Strategy = *integrate as components of quality system*	Interface = SSGP Strategy = *resource mgt through farming*

Figure 7.7 A Matrix for Classifying the Case Study Programmes

5.0 Conclusion

This investigation of the NZ dairy sector has focused on the use of research, science and technology to build a sustained and internationally competitive sector performance. Several contributions to technology management literature emerged as a consequence of the case study investigations.

1. The CIDR case study distinguished between an analytical level of action and a concrete level of actors and material objects. The analysis of practices, being the way actors perform sequences of activities to solve their problems, revealed technology to be an embodiment of practice. Technology enables actors to convey the rules of practice to others.
2. Viewing technology as practice distinguished the Interplay Model from the AKS perspective, building on the latter by 'unpacking' the learning experiences embodied in the management of technology. The separation of instrumental, strategic and communicative rationalities in AKS are combined in practice analysis. Furthermore, using the Interplay Model distinguished between the emergent stages of the CIDR development work as it evolved towards a synchronising technology.
3. Learning experiences in the CIDR case study were identified as the development of defining and experience rules. Defining rules helped distinguish the aspects of competence (normative way) and performance (actual doing) and experience rules helped combine these aspects in strategic activity. It is the rules that give a unity to

practice, and hence actors attempted to embody these rules in the CIDR device with its accompanying protocols.

4. Practices are a unity of competent performance, but the SSGP identified a continuous movement in emphasis on the combined aspects of performance during the development of new technology. The development of hardware required developments in concepts and social networks to weigh stock, monitoring pugging and build models for nutrient balancing. Similarly, the different aspects of competence were emphasized in the evolution of technology.
5. However it was found in the CIDR case that strategy did not emerge from the rules of practice as originally specified in the Interplay Model. Strategy, as the processing of possibilities, was performed as a sequence of activities that combined all the aspects of performance. Strategy has experience rules combining the aspects of performance consistent with the defining rules of practice.
6. A normative dimension to strategy was identified in the SSGP, whereby integrity combined the aspects of competence as an emergent property of practice. As the actors worked towards resource management through farming, a different notion of farming emerged - a collective integrity combined with a collective strategy forming a unity of practice.
7. Extending a practice is a practice in itself - a mediating practice. The SAMM study identified a specialised interface that enabled practices to interplay in such a way that a sector-wide mastitis management programme was launched and functioned to lower the BMSCC of the national herd. Mediating practice is a way of interplaying that does not necessarily depend on a third party mediation.
8. Harmony in the sector was distinguished from the term synergy as used in the AKS perspective. Harmony is a working out of sector performance, not necessarily without competition, but as an interactive performance towards a shared desirable outcome.
9. Achieving harmony in a sector can be achieved through muddling through, as in the SAMM case study. Alternatively, methodologies can be developed and employed to reduce uncertainty and possibly reduce transaction costs by implicitly using muddling through strategies. The SSGP used general participatory methodologies to assist with the evolution of technology.
10. It was suggested in this chapter that the development of methodologies for mediating practice is a critical post-reforms requirement for the NZ dairy sector to improve the processing of possibilities that emerge from using new technology, and to capitalise on the opportunities emerging from the reforms for a competitive sector performance.

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Glossary

action: what actors do, acting in response to phenomena under a specific set of perceived conditions

actor: the human entity performing in theatres of innovation as an independent individual, but may also refer to collectives of individuals as represented by formal organizations, or as represented by informal collective action groups. Actors possess agency.

agency: the capacity for voluntary action.

agriculture: the husbandry of soil:plant:animal interactions by actors.

AKS: Agricultural Knowledge System - a social research perspective referring to a dynamic social domain of knowledge development and/or use that may benefit those actors who interact in that domain.

alliance: a commercial arrangement for pooling resources for a common benefit.

attitude: a stable predisposition to react in certain ways towards persons, objects, institutions or issues.

boundary spanners: are individuals who engage in networking tasks and employ methods of coordination and task integration across organisational boundaries.

case study: a research design that takes as its subjects a specific social entity

category: A classification of concepts. This classification is discovered when concepts are compared one against another and appear to pertain to a similar phenomenon. Thus the concepts are grouped together under a higher order, more abstract concept called category.

change: the alteration of conditions of sufficient degree that it brings about a corresponding change in action/interaction strategies.

client: an actor who expects and/or receives beneficial outcomes from the provision of technologies in exchange for some form of payment.

Coding: the process of analysing data

collaboration: actors joining resources to work for a common cause, usually in the form of a joint venture or strategic alliance, as opposed to a competitive relationship with another actor.

collective action: work in combination with others, often used interchangably with collaboration, though focused more on the work process component of a collaborative arrangement.

collective learning: a process of inquiry that involving two or more actors in mutual investigation.

collective strategies: visions that aspire to have actors working together to process possibilities.

commerce: a social institution of trade.

communication: exchanging concepts using symbols, usually language. Communication is essential to any co-operative activity.

compatability: an attribute of two or more actors to accommodate each other.

competence: appropriateness of ability for a task, includes aspects of positioning, representing, judging and executing

competent performance: discharging competence in task performance.

competition: whereby actors oppose one another in the pursuit of their goals.

competitive co-operation: whereby some actors work together to compete against other actors perceived to be competitors.

concept: ideas that actors use to understand, events, and other phenomena.

conflict: disagreement, disharmony and strife about objectives, methods, and policies between actors and organisations in an interorganisational network.

constructivism: theories that emphasize the socially constructed nature of life. Social worlds are interpretive nets woven by individuals and groups.

context: the specific set of properties that pertain to a phenomenon; the location of events or incidents pertaining to a phenomenon along a dimensional range. Context represents the particular set of conditions within which the action/interaction strategies are taken.

contingency: an unanticipated/unplanned happening that brings about a change in conditions.

contract: a voluntary agreement between independent actors specifying the rights and duties of both parties in an exchange.

cooperation: actors working together harmoniously.

coordination: the articulation of actions towards goals that are common among actors.

core category: the central phenomenon around which all the other categories are integrated.

customisation: specialisation of technologies for a discerning client.

decision-making: choosing between alternative courses of action.

design: a modelling response to actor needs which embodies intentions as technologies using a creative process.

dilemma: a decision circumstance where choice is made difficult because of conflicting preferences for outcomes from alternative courses of action.

dimensions: location of properties along a continuum.

discipline: a self aware group of actors who share perceptions of what constitutes competent performance in their shared domain of work.

evolution: continuous change towards a higher status of being.

exchange: actors give and receive reciprocally.

expectation: an actors anticipation of forthcoming events or actions.

experiential learning: learning based on experience.

expertise: recognition among actors of an actors competent performance in a specialised domain of action.

farm management: the pattern of actions that regulate the use of farm resources consistent with farmer goals.

feedback: communicative responses to messages received from other actors.

firm: a profit seeking organization.

flexibility: ability to act in different ways.

goals: an objective towards which an actor strives.

governance: the actions that regulate and control the activities of other actors.

group: where two or more actors perceive themselves to be members of the same social category that is recognised by at least one other actor not in that same category.

harmony: the way actors combine and progress in a theatre of innovation.

identity: relative integrity of representation by actor to self and others.

identity crisis: the failure of actors to align their perception self with representations of their self to others.

individual: human entity who expresses to some degree self awareness and integrity of existence, contrasts with collective identity.

information: the organization of data into patterns amenable to manipulation by actors to construct knowledge.

innovation: creative responses to events by actors, sometimes packaged as technologies for application in subsequent circumstances.

institution: an established aspect of society, a type of super custom (eg. law, church, family etc.)

integration: linkage of actions.

interaction: people doing things together or with respect to one another - with accompanying communicative and cognitive processes.

interdependency: a mutual dependence among actors to achieve their independent goals.

interface: the means by which interplay (i.e. ongoing interaction) is effected at the place where multiple intersections of different practices occur. Connectibles; joint performances; broker practices.

inter-organisational collaboration: where independent organisations determine to work together for mutual benefit.

interplay: the combination of activities in such a way that new forms of activity emerges as a pattern of competent performance not previously conceived.

intervening conditions: the structural conditions bearing on action/interactional strategies that pertain to a phenomenon. They facilitate or constrain the strategies taken within a specific context.

learning: the way information is constructed into knowledge.

linear technology transfer: A functional representation of technology transfer whereby technology is developed by scientists and is then extended by professionals to farmers.

linkage: connecting actors or actions, often in the context of networks: obligational, production, promotional.

market: an institution concerned with the trading activities of actors.

metaphor: an allegory, a fiction with a meaning beyond the literal.

model: a conceptualisation that attempts to represent reality as a simplified system of interacting components.

memo: written records of analysis related to the formulation of theory.

monitoring: protocols and tools that facilitate collective observations by actors.

needs analysis: investigation of actor requirements for growth and development.

negotiation: a communicative process that seeks to resolve divergent interests of actors and avoid social conflict.

network: The set of linkages, representing transactions and relationships, between actors. Networks constitute a basic social form that permits interactions, concerted action, and joint production. Networks are unbounded or bounded clusters of actors that, by definition, are non-hierachical collectives of legally separate units - networks are a special for of actor. Networks provide a way of mapping the social terrain. Networks are found in multiple forms and vary along a number of dimensions: size, mutuality, complexity, extensiveness, and distinctiveness of boundaries.

networking: is the act of creating and/or maintaining a cluster of actors for the purpose of interplaying, acting, or producing among the member actors.

niche market: a comparatively small domain of trading in specialised technologies.

objectives: formalised expressions of actor intentions.

organisation (formal): A legal entity that emerges at an ascertainable moment in time; possessing controlled and co-ordinated patterns of social relations; and that plans for change in social relations to improve performance. The social arrangement of actions centre on core productive activities to which all other activities in the organisation can be orientated. The goals of the formal organization may bear no relations to the goals of the actors in that organization. Goals may be multiple, conflicting and displaced.

organisation (informal): Informal groups of actors within formal organizations that have an internally derived status system, behavioural patterns, beliefs and objectives to satisfy those needs of actors that are not supplied by the formal organization.

organisational culture: heritage of values, norms and competencies shared by actors in an organization.

paradigm: concept [further developed by Kuhn] that encompasses the whole of conceptions, norms, values, methods and techniques shared by a group of scientists to guide the design of research.

paradox: a self-contradictory situation or concept, that an improved understanding reveals as only apparent self-contradiction.

participation: entering into joint work with other actors.

participatory action research: the involvement of actors that are subjects of study in the research process.

partnering: evolving interdependence of actors to perform a practice.

performance gap: the difference between actual and intended performance.

perspective: an actors subjective or practical theories - an actors beliefs.

phenomenon: the central idea, event, happening, incident about which a set of actions or interactions are directed at managing, handling, or to which the set of actions is related.

policy: an articulated set of ideas about what should be done in a particular sphere, which is often set down in writing, and usually formally adopted by the relevant decision making body. Policy is formulated at a general level to indicate the objectives and intended direction of change - whereas plans specify in detail the way in which objectives are to be achieved.

practice:

General: A social domain of action. Practice refers to human action taken on the natural (hard system) and social (soft system) world. The generally accepted and shared, habitual, taken-for-granted ways of doing, understanding, communicating and cooperating.

Professional P.: Professional P. stipulates the actions, materials and concepts that practitioners share in their work. Professional P. constitutes the new recruits basic question - 'how are things done around here?' They include arrangements, methods, procedures, schemes, and techniques as categories of the collective aspect of coping and accomplishing. Professional P. May apply to a more specific distinction between Technical and Scientific work, though 'the Professional' usually refers to the technical practitioner (cf. Researcher for scientific practitioner).

Broker P.: A practice that emerges by combining aspects of two or more professional P. Broker P. are unique possess identity in their own right and are part of an evolutionary continuum of practice. The substantive concerns of a Broker P. pertain primarily to hard system issues.

Mediating P.: The practice of interplay, primarily concerned with the soft system dimension of emerging practice in relation to issues of technology management. A Mediating P. possesses its own tools (or methodologies), routines (performed by the mediating practitioners) and knowledge resources that are combined to improve the harmony among actors in an AKS. A Mediating P. may facilitate the evolution of a Broker P. by improving the conditions of interplay, often by fostering the sharing of learning experiences among Broker P. Practitioners.

practitioner: that actor who performs a practice.

problem-solving: cognitive action that attempts to achieve an ideational solution to a problem.

process: the linking of action/interactional sequences as they relate to a phenomenon.

product: the tangible attributes of a technology.

profession: a group of practitioners who share a practice that is appreciated by the wider community.

programme: a specialised domain of social action that formalises the interface of practices to deliver outcomes in exchange for funds. Research programmes encompass the interpretative theoretical orientation and properties of the research domain, contain heuristics that block (negative) and stimulate (positive) new ways of doing research - see Lakatos [research programme].

properties: attributes or characteristics pertaining to a category.

public good: goods that cannot be withheld from any actor.

public responsibility: a collective, partially self-perceived and continuously evolving, code of social conduct shared by all actors in society.

quality: a socially constructed expectation of technologies.

reciprocity: actions pertaining to the alternating interplay among actors.

regulation: formal restrictions on the actions of actors.

relationships: the orientations of actors to one another, variously represented as biologic or symbolic.

research and development: research activities inquire into why phenomena behave in observed ways, development seeks to harness the outcomes of inquiry for social purposes.

resource dependency: the degree to which a network of organisations uses external resources from a single source for survival and goal achievement.

risks: the implications for actors operating in a world of uncertainty, actors can use measurement methods to reduce risks and perform in a world of uncertainty.

routines: the often implicit behaviour of actors performing familiar actions.

rules: actors rational guidelines that define the natural world, and that define the actors relationship to other actors. Rules are constructed as the actor accumulates experience.

Sampling (Theoretical): sampling on the basis of concepts that have proven theroetical relevance to the evolving theory - proven theoretical relevance: indicates that concepts are deemed to be significant because they are repeatedly present or noteably absent when comparing incident after incident, and are of sufficient importance to be given the status of categories.

science: an institution that constructs knowledge at the highest level of generalisation for public consumption.

sector: a social domain of action that is discriminated in society by its production systems and the outputs of these systems.

service: actions that offer benefits to clients.

skills: attributes of actors to act according to expectation.

social responsibility: the obligation to enrich society through actions that contribute to the public good; social responsibility in Business: the purpose that business exists to enrich society and reward those responsible for the enriching.

Society: the group of all actors that recognise themselves as a unique cultural and territorial entity.

soft systems methodology: the application of systems thinking to the dynamic world of human perceptions. Perceptions pertain to hard systems (physical and biological systems) and soft systems (perceptions of social systems), soft system methodology is a way of actors coming to view *themselves* as a soft system.

strategy: relatively consequential intentions and their ensuing actions; strategy has dimensions of positioning and perspective.

sustainability: the enduring attributes of an entity.

system: a conceptualisations of interelated components, ordered heirarchically, specifying boundary conditions and the input: output relationships.

task: a descrete action by an actor. Tasks are sequentially ordered to form a pattern of activities that ultimately constitute a practice.

technology: the hardware (seeds and machinery), methods (husbandries and marketing) and increments in knowledge (practical and scientific) used in agricultural systems.

Technology management: the development, distribution and use of technology by farmers, researchers and professionals to resolve systemic problems or expand opportunities.

theatre: a metaphor representing domains of activity as a stage with interplaying actors seek harmony among their individual performances to generate an emergent activity - the collective activity.

theory: an account of the world that goes beyond what we can see and measure. A systematic ordering of concepts and understanding of the empirical world.

transactional system: a system of analysis that examines action/interaction in relationship to their conditions and consequences.

transaction cost analysis: the investigation of costs accrued during interplay among actors.

trust: an actors confidence in the reliability of another actor, implicit faith in another.

uncertainity: error in predicting the behaviour of phenomena, the fact of ignorance and necessity of acting upon opinion rather than knowledge.

vertical dependency: reliance on actors who precede and follow in a sector alignment situation.

vertical integration: linkage among actors who precede and follow in a sector alignment situation.

work status: the societal valuation of an actors domain of work.

workers: actors who perform tasks.

Appendices

Appendix One: Empirical Descriptions of Case Studies

CIDR

Data pertaining to the activities of actors involved in the development and of the CIDR device was gathered by semi-structured interviews (see Appendix Two) and focus groups with 18 key informants. These informants included farmers, researchers, veterinarians, manufacturers, competitors and marketers. The interviews averaged 2 hours, each being recorded and transcribed to generate about 15,000 words of text per interview. Interview data was supplemented with secondary material gathered from the NZ Dairy Exporter (NZDE), science papers and conference proceedings[1]. The NZDE is a monthly sector publication reporting on market and technological developments in the dairy sector. Each secondary data source was exhaustively searched for articles relating to CIDR from 1986, the year of commercial release, to 1996. Text data was analysed using NUD.IST™ revision 3 (Non-numerical Unstructured Data Indexing Searching and Theorizing). This computer based programme was used when coding and comparing *online* transcripts and *offline* secondary data using Grounded Theory principles. A total of 18 on-line documents were coded - allocating 5108 text units[2] to 130 nodes (see below).

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Mark S. Paine.

PROJECT: CIDR_IND, User Mark S. Paine

(1) /date interviewed
(1 1) /date interviewed/questions
(2) /analyses
(2 1) /analyses/matrices
(2 1 1) /analyses/matrices/tech purpose
Matrix Node.
(2 1 3) /analyses/matrices/sys-links
Matrix Node.
(2 2) /analyses/vectors
(2 2 1) /analyses/vectors/routn-build
Matrix Node.
(2 2 2) /analyses/vectors/emer-criteria
Matrix Node.
(2 2 3) /analyses/vectors/com-negotiate
Matrix Node.
(2 3) /analyses/other searches
(2 3 1) /analyses/other searches/explore
(2 3 2) /analyses/other searches/routine
(2 3 3) /analyses/other searches/emergence
(2 3 4) /analyses/other searches/org-strat
(2 3 4 1) /analyses/other searches/org-strat/IndSysSrch
(2 3 5) /analyses/other searches/commercial
(2 3 6) /analyses/other searches/partnering

[1] Ruakura Dairy Farmers Conference and NZ Society of Animal Production.
[2] A text unit can be a word, phrase, sentence or paragraph(s) containing a significant event or idea.

(10) /T as practice
(10 1) /T as practice/P. practice
(10 1 1) /T as practice/P. practice/techn adaptn
(10 1 1 4) /T as practice/P. practice/techn adaptn/techn refine
(10 1 1 4 1) /T as practice/P. practice/techn adaptn/techn refine/control
(10 1 1 4 2) /T as practice/P. practice/techn adaptn/techn refine/roles
(10 1 1 4 3) /T as practice/P. practice/techn adaptn/techn refine/improvement
(10 1 1 4 5) /T as practice/P. practice/techn adaptn/techn refine/precursors
(10 1 1 5) /T as practice/P. practice/techn adaptn/Techn linkage
(10 1 1 5 1) /T as practice/P. practice/techn adaptn/Techn linkage/synergy
(10 1 1 5 2) /T as practice/P. practice/techn adaptn/Techn linkage/displacement
(10 1 1 5 3) /T as practice/P. practice/techn adaptn/Techn linkage/natural cycle
(10 1 1 5 4) /T as practice/P. practice/techn adaptn/Techn linkage/recovery
(10 1 1 5 5) /T as practice/P. practice/techn adaptn/Techn linkage/unlock power
(10 1 1 5 6) /T as practice/P. practice/techn adaptn/Techn linkage/adaptive use
(10 1 1 5 7) /T as practice/P. practice/techn adaptn/Techn linkage/inventive
(10 1 1 5 8) /T as practice/P. practice/techn adaptn/Techn linkage/resource Nw
(10 1 1 5 9) /T as practice/P. practice/techn adaptn/Techn linkage/hierarchy
(10 1 3) /T as practice/P. practice/routine perform
(10 1 3 1) /T as practice/P. practice/routine perform/implicit DM
(10 1 3 3) /T as practice/P. practice/routine perform/preference
(10 1 3 3 2) /T as practice/P. practice/routine perform/preference/simplicity
(10 1 3 3 3) /T as practice/P. practice/routine perform/preference/environment
(10 1 3 5) /T as practice/P. practice/routine perform/task acts
(10 1 3 5 4) /T as practice/P. practice/routine perform/task acts/tradition
(10 1 3 5 5) /T as practice/P. practice/routine perform/task acts/dynamics
(10 1 3 5 6) /T as practice/P. practice/routine perform/task acts/dependence
(10 1 3 5 8) /T as practice/P. practice/routine perform/task acts/Act~seasons
(10 1 3 5 11) /T as practice/P. practice/routine perform/task acts/experience
(10 1 6) /T as practice/P. practice/commercial
(10 1 6 10) /T as practice/P. practice/commercial/strategy
(10 1 6 14) /T as practice/P. practice/commercial/systems
(10 1 6 14 1) /T as practice/P. practice/commercial/systems/sys mgt pack
(10 1 6 14 2) /T as practice/P. practice/commercial/systems/sys rethink
(10 1 6 14 3) /T as practice/P. practice/commercial/systems/sys entrench
(10 1 6 15) /T as practice/P. practice/commercial/emergence
(10 1 6 15 1) /T as practice/P. practice/commercial/emergence/mutuality
(10 1 6 15 2) /T as practice/P. practice/commercial/emergence/property right
(10 1 6 15 3) /T as practice/P. practice/commercial/emergence/independence
(10 1 6 15 4) /T as practice/P. practice/commercial/emergence/creative links
(10 1 6 15 5) /T as practice/P. practice/commercial/emergence/payoff
(10 1 6 15 6) /T as practice/P. practice/commercial/emergence/critical mass
(10 1 6 15 7) /T as practice/P. practice/commercial/emergence/professionalism
(10 1 6 15 8) /T as practice/P. practice/commercial/emergence/networking
(10 1 6 15 9) /T as practice/P. practice/commercial/emergence/mkt expand
(10 1 6 15 10) /T as practice/P. practice/commercial/emergence/channel align
(10 1 6 15 11) /T as practice/P. practice/commercial/emergence/competition
(10 1 6 15 12) /T as practice/P. practice/commercial/emergence/Nw tradition
(10 1 6 15 13) /T as practice/P. practice/commercial/emergence/commit risk
(10 1 6 15 14) /T as practice/P. practice/commercial/emergence/rejection
(10 1 6 15 15) /T as practice/P. practice/commercial/emergence/expectation
(10 1 6 16) /T as practice/P. practice/commercial/criteria
(10 1 6 16 1) /T as practice/P. practice/commercial/criteria/risk@mkt
(10 1 6 16 2) /T as practice/P. practice/commercial/criteria/legislation
(10 1 6 16 5) /T as practice/P. practice/commercial/criteria/feasibility
(10 1 6 16 8) /T as practice/P. practice/commercial/criteria/funding
(10 1 6 16 9) /T as practice/P. practice/commercial/criteria/disclosure
(10 1 6 16 10) /T as practice/P. practice/commercial/criteria/mkt needs

(10 1 6 16 11) /T as practice/P. practice/commercial/criteria/time
(10 1 6 16 12) /T as practice/P. practice/commercial/criteria/simple solns
(10 1 6 16 13) /T as practice/P. practice/commercial/criteria/property protectn
(10 2) /T as practice/orgn community
(10 7) /T as practice/change
(10 7 1) /T as practice/change/new Techn
(10 7 2) /T as practice/change/new channels
(10 7 3) /T as practice/change/competiive reaction
(10 7 4) /T as practice/change/valuation
(10 8) /T as practice/negotiation
(10 8 1) /T as practice/negotiation/prog perf<expect
(10 8 2) /T as practice/negotiation/position claim
(10 8 3) /T as practice/negotiation/resource~sector access
(10 8 4) /T as practice/negotiation/high level mediatn
(10 8 5) /T as practice/negotiation/system level dilemmas
(10 9) /T as practice/sector prosperity
(10 9 1) /T as practice/sector prosperity/sustainability
(10 9 2) /T as practice/sector prosperity/comparative perfm
(10 9 3) /T as practice/sector prosperity/rivalry
(10 9 4) /T as practice/sector prosperity/learn facilities
(10 9 5) /T as practice/sector prosperity/structures
(10 9 6) /T as practice/sector prosperity/retain advantage
(10 9 7) /T as practice/sector prosperity/initial conditions
(10 10) /T as practice/confidence
(10 10 1) /T as practice/confidence/sensemaking
(10 10 1 11) /T as practice/confidence/sensemaking/inquiry
(10 10 1 11 2) /T as practice/confidence/sensemaking/inquiry/challenge practice
(10 10 1 11 3) /T as practice/confidence/sensemaking/inquiry/design
(10 10 1 11 5) /T as practice/confidence/sensemaking/inquiry/explore unknown
(10 10 1 11 7) /T as practice/confidence/sensemaking/inquiry/outside view
(10 10 1 11 8) /T as practice/confidence/sensemaking/inquiry/vision limits
(10 10 1 11 9) /T as practice/confidence/sensemaking/inquiry/risk errors
(10 10 1 12) /T as practice/confidence/sensemaking/ordering
(10 10 1 12 1) /T as practice/confidence/sensemaking/ordering/explain power
(10 10 1 12 3) /T as practice/confidence/sensemaking/ordering/monitoring
(10 10 1 12 4) /T as practice/confidence/sensemaking/ordering/system response
(10 10 1 12 6) /T as practice/confidence/sensemaking/ordering/translate
(10 10 1 12 10) /T as practice/confidence/sensemaking/ordering/commun style
(10 10 2) /T as practice/confidence/work results
(10 10 2 8) /T as practice/confidence/work results/build routine
(10 10 2 8 6) /T as practice/confidence/work results/build routine/trial & error
(10 10 2 8 7) /T as practice/confidence/work results/build routine/creat pract soln
(10 10 2 8 9) /T as practice/confidence/work results/build routine/C:B evaln
(10 10 2 8 10) /T as practice/confidence/work results/build routine/tgt enterprise
(10 10 2 9) /T as practice/confidence/work results/info role
(10 10 2 9 1) /T as practice/confidence/work results/info role/arbiter truth
(10 10 2 9 2) /T as practice/confidence/work results/info role/lead inquiry
(10 10 2 9 5) /T as practice/confidence/work results/info role/loss
(10 10 2 9 7) /T as practice/confidence/work results/info role/counter status threat
(10 10 2 10) /T as practice/confidence/work results/decision rule
(10 10 2 10 3) /T as practice/confidence/work results/decision rule/cause and effect
(10 10 2 10 4) /T as practice/confidence/work results/decision rule/logic of choice
(10 10 2 10 5) /T as practice/confidence/work results/decision rule/why cidr
(10 10 2 10 6) /T as practice/confidence/work results/decision rule/change judge

SAMM

Similar to the CIDR, data was gathered on the activities of actors involved in the SAMM programme using semi-structured interviews (see Appendix Two), focus groups and participant observation of farm discussion groups. Key informants included farmers, researchers, veterinarians, agrichemical marketers and consultants. Interviews and farm discussions were recorded and transcribed. Selectively coding these transcriptions, using the constant comparative method, generated 20 nodes from 24 on-line documents. A total of 1741 text units were required to generate these codes (see below). Interview data was supplemented with secondary material gathered from the NZ Dairy Exporter (NZDE), science papers and conference proceeding. Each secondary data source was exhaustively searched for articles relating to mastitis management and SAMM from 1990 to 1996.

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Mark S. Paine.

PROJECT: SAMPLAN, User Mark S Paine.

(1)	/problem domain
(1 1)	/problem domain/individual
(1 1 1)	/problem domain/individual/intent
(1 1 2)	/problem domain/individual/attainment
(1 2)	/problem domain/collective
(1 2 1)	/problem domain/collective/intent
(1 2 2)	/problem domain/collective/attainment
(2)	/mediating practice
(2 1)	/mediating practice/learning
(2 2)	/mediating practice/legislating
(2 3)	/mediating practice/structuring
(4)	/managing mastitis
(4 1)	/managing mastitis/decisions
(4 2)	/managing mastitis/performance
(4 2 1)	/managing mastitis/performance/tools
(4 2 2)	/managing mastitis/performance/tasks
(4 2 3)	/managing mastitis/performance/knowledge
(4 3)	/managing mastitis/dilemmas
(10)	/analyses
(10 3)	/analyses/identity

SSGP

This case study used an action research strategy to examine activities in the sustainability study groups. Action research enabled the documentation of activities in the field as actors perform their routine work. Observations span from the first group meeting through to the public profiling of group achievements. A combination of note taking and audio and video recording generated 29 on-line documents. These documents were coded using Nudist, requiring 14,500 text units that generated 57 codes following conventional grounded theory procedures (see below). Secondary data, including reports, papers and bulletins, complemented the on-line database.

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Mark S. Paine.
PROJECT: SSGP, User mark s paine.

(1) /analyses
(1 1) /analyses/IndSysSrch
Matrix Node.
(1 2) /analyses/needs
(1 2 1) /analyses/needs/dilemma
(1 2 2) /analyses/needs/goals
(1 2 2 1) /analyses/needs/goals/dependence
(1 2 2 2) /analyses/needs/goals/problem defn
(1 2 3) /analyses/needs/responsibility
(1 2 4) /analyses/needs/design
(1 2 5) /analyses/needs/criteria
(1 2 6) /analyses/needs/operate system
(3) /problem defn
(3 6) /problem defn/structure
(3 6 1) /problem defn/structure/design
(3 6 2) /problem defn/structure/need
(3 6 2 2) /problem defn/structure/need/farming
(3 6 2 3) /problem defn/structure/need/organisational
(3 6 2 4) /problem defn/structure/need/sector
(3 6 2 5) /problem defn/structure/need/scisystem
(3 6 5) /problem defn/structure/resources
(3 6 6) /problem defn/structure/roles
(3 6 6 3) /problem defn/structure/roles/member
(3 6 6 4) /problem defn/structure/roles/client
(3 7) /problem defn/process
(3 7 3) /problem defn/process/decision-m
(3 7 4) /problem defn/process/strategy
(3 7 5) /problem defn/process/learning
(3 7 5 1) /problem defn/process/learning/questioning
(3 7 5 2) /problem defn/process/learning/interacting
(3 7 5 3) /problem defn/process/learning/instruction
(3 8) /problem defn/content
(3 8 1) /problem defn/content/language
(3 8 2) /problem defn/content/tasks
(3 8 3) /problem defn/content/tools
(5) /integrity
(5 1) /integrity/risk
(5 2) /integrity/resources
(5 2 1) /integrity/resources/people
(5 2 2) /integrity/resources/measure sys
(5 3) /integrity/context
(5 3 1) /integrity/context/sector need
(5 3 4) /integrity/context/orgn culture
(5 4) /integrity/evolution
(5 4 1) /integrity/evolution/partnering
(5 4 1 1) /integrity/evolution/partnering/betwn professn
(5 4 1 2) /integrity/evolution/partnering/brokering
(5 4 1 3) /integrity/evolution/partnering/within professn
(5 4 1 4) /integrity/evolution/partnering/sector
(5 4 2) /integrity/evolution/transfer
(5 4 4) /integrity/evolution/concept building
(5 4 5) /integrity/evolution/maturation
(5 4 5 1) /integrity/evolution/maturation/establish
(5 4 5 2) /integrity/evolution/maturation/develop
(5 4 5 3) /integrity/evolution/maturation/emerge

Appendix Two: Interview Guidelines for CIDR and SAMM Case Studies

CIDR Interviews

Interview Questions

The Respondent

1. What has been your role in the development and use of CDIR devices?
2. What is your current relationship to others involved with CDIR technology?
3. What critical tasks must be performed by your group for CDIR adoption to be successful?
4. Are you dependent on others to perform certain critical tasks, are others dependent on you?
(who and why?)

The Technology

1. Where did the idea of a CDIR device originate?
2. What critical activities ensured it became a commercially viable technology?
3. What is your group's involvement now?
4. How do you protect the intellectual property embodied in CDIR?
5. What other technologies have been spawned or integrated with CDIR?

The Activities and Interactions

6.Who are the key groups involved with the development and use of CDIR and what are their roles?
7. What obligations and responsibilities does your firm have when developing/using CDIR devices?
8. How do contractual agreements influence the level of trust among the groups involved with CDIR's?
- What factors reinforce trust among groups?
- How do personal relationships and contractual agreements influence the development and use of CDIR's
9. How critical was Government funding in the development phases of CDIR?
- how was the transition to commercial funding made
- what was critical to the success of the transition
- do Government funds have any role now
- if Government funds were used, what could Government reasonably expect in return?
10. Are there risks of negative publicity when involved with public research institutes in the development of technologies like CDIR?
11. How were power relations negotiated among the parties
- regulation of resources (funds, knowledge, release of devices)
- sharing of benefits
- formulation of plans
12. How did/do parties request and give consent to changes in agreed action plans?
13. What disagreements developed among parties?
- how did they arise
- what happened

- how were they resolved
14. Did/do administrative details delay innovations?
- what role do they have
- how are they reviewed for improvement
15. How are suggested product improvements captured?
16. How do you monitor the adoption and market performance of the device?
17. How has the development/use of the device influenced internal relations?
18. Who are the important sources of information to you regarding further opportunities with the device?
- the people, their relation to the company, and the types of ideas
- processes for continual improvement, ideas capture.
19. Number of employees/ turnover/products/life of firm?
20. Any other issues that have not been raised regarding the collaborative development and use of CDIR?

Farmer Focus Group Question Guidelines

Farm Description

- farm size & Location
- number of cows
- type of cows
- make-up of herd [heifers; lactating cows; empties; No of bobby calves]
- stocking rate
- feed supply this season
- drying off date
- expectations for spring
- calving date
- number of inductions

Views on Synchronising Heifers, non-cyclers and whole herd

- Reasons for doing [not doing] it
- how do you synchronise
- Where do synchrony jobs fit in your seasonal work pattern
- what factors are critical to success [level of control over those factors listed]
- why have you used [not used] CIDR
- plans for next year
- what are the costs and benefits to you of using CIDR

Support Services

- Who are the critical people to getting a good result with CIDR [where do they fit in your work programmes]
- What programmes are available [where are they accessed; competitor programmes]
- Have there been any difficults with contractual arrangements when using CIDR
- Need for improvements CIDR and commercial synchrony programmes
- Any other issues that have not been raised regarding the use of CDIR?

SAMM
Farmer Focus Group Guidelines

Farm Description
- farm size and location
- number of cows
- type of cows
- make-up of herd [heifers; lactating cows; empties; No of bobby calves]
- stocking rate
- feed supply this season
- drying off date
- expectations for spring
- calving date
- SCC status through the season [into grades?]

Mastitis Management Activities
- Reasons for mastitis developing in herds - critical factors
- how do you manage mastitis
- Where do the jobs to manage mastitis fit in your seasonal work pattern
- what factors are critical to successful control [level of control over those factors listed]
- why have you used [not used] SAMM plan [5 point plan]
- control plans for next year
- what are the costs and benefits to you of using SAMM plan

Support Services
- Who are the critical people to getting a good result with mastitis control [where do they fit in your work programmes]
- What programmes are available [where are they accessed; competitor programmes]
- Have there been any difficults with contractual arrangements when using SAMM plan
- Need for improvements in SAMM plan and mastitis control programmes
- Any other issues that have not been raised regarding the use of SAMM plan?

Appendix Three: Sample NUDIST Reports

A wide variety of reports can be generated from NUDIST to assist the analyst working through the coding and theorising process. Examples of these reports are attached below to indicate to the reader the data presentation capabilities of the software. These reports are not intended as definitive overviews of the case study data.

A matrix search command for extracting text units that intersect nodes

Analysts can use a range of search commands to access text units from multiple documents at any node. Furthermore, text units can be extracted from multple nodes using the matrix search command. This command searches all text units and extracts those that are common among those nodes that cluster beneath two selected subsuming nodes. The report specifies those text units found at each combination of

nodes. The example below was taken from the CIDR case study and has been amended to remove confidential information.

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Mark S. Paine.

PROJECT: CIDR_IND, User Mark S. Paine

```
**************************************************************************************
(2 1 3)          /analyses/matrices/sys-links
*** Definition:
Search for (MATRIX INTERSECT (10 1 6 14) (10 1 1 5))
Matrix Node.
######################################################################################
### Cell (1 1)
### (INTERSECT (10 1 6 14 1) (10 1 1 5 1))
++++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: D---
+++ Retrieval for this document: 1 unit out of 173, = 0.58%
* MP: CLARIFY WHAT YOUR ROLE WAS FROM THE START WITH CIDR                    5
++ Text units 34-34:
D--: Looking at that business, I don't .... the market is small and erratic so development has
been going on for sometime and nothing has really happened. Some
spin-off technologies have come from the z-- b---. These technologies
break into new markets. I don't think .... exploited that
potential.                                                  34

######################################################################################
### Cell (1 2)
### (INTERSECT (10 1 6 14 1) (10 1 1 5 2))
## This cell indexes no documents.
######################################################################################
### Cell (1 3)
### (INTERSECT (10 1 6 14 1) (10 1 1 5 3))
++++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: K---
+++ Retrieval for this document: 1 unit out of 315, = 0.32%
*MSP: THROUGH THE DAIRY INDUSTRY?                                  41
++ Text units 42-42:
K--: Through the dairy industry. What we are trying to do, the normal
dairy producer will use AB for 6 weeks, and then use his bull for another
6-9 weeks, and almost all the cows that get into calf to the bull will be
induced to calf prematurely. It's more or less the T-- type model.
If you get 50% of all your cows pregnant in the 1st 3 weeks; 25% in the
2nd 3 weeks; and 12.5% in the 3rd 3 weeks. It more or less goes down
like that - in actual fact it starts a bit higher, but it slope off
because within a herd of 100 cows, there may be 4% that subfertile or
infertile. So they are 4% initially, but when we get down to here they
start representing a larger number. This is taking 12 weeks, by which
time theoretically you still have another 6.25 that are not pregnant.
With the synchrony concept, the 1st 3 weeks takes 1 day. Which means we
can take one round off. It depends on where you want to start in terms
of the cycling round to be removed. What this means, is that if it was
the 2nd 3 week cycle (and it won't be quite 25% because you take the
empties out) but none the less, are out of this population of 25%, and we
have halved it, if it's 12.5.% of the animals that could be induced, that
includes the cows that are not pregnant (which is the 6.25%). So we have
```

actually brought our induction rates down to 6.25%. What has also happened is that, whereas these induced cows don't produce calves that live, now all of these cows are producing calves that live. And if we've synchronised our heifers that were previously mated by Hereford or an Angus bull, you can see all of a sudden we've got a surplus of replacements. So it may well be that we only use Friesian semen for the first 2 rounds, which we do in 3 weeks, because we can switch into the others later (we've never been able to do that before). Previously these cows were candidates for induction. Now they have to be inseminated. Because if we are in a 300 cow herd, we have too many animals for a bull to handle, but because it only takes 3 days to inseminate them, and if people can sell replacements - and they will (like Friesian bull, or you can sell a freshen heifer) but in a Jersey herd, it may pay to put in some trendy line. But that hasn't happened yet. 42

##
Cell (1 4)
(INTERSECT (10 1 6 14 1) (10 1 1 5 4))
This cell indexes no documents.
##
Cell (1 5)
(INTERSECT (10 1 6 14 1) (10 1 1 5 5))
This cell indexes no documents.
##
Cell (1 6)
(INTERSECT (10 1 6 14 1) (10 1 1 5 6))
This cell indexes no documents.
##
Cell (1 7)
(INTERSECT (10 1 6 14 1) (10 1 1 5 7))
This cell indexes no documents.
##
Cell (1 8)
(INTERSECT (10 1 6 14 1) (10 1 1 5 8))
++
+++ ON-LINE DOCUMENT: H---
+++ Retrieval for this document: 1 unit out of 365, = 0.27%
*MP: DID YOU DO THE GENOMATE PROGRAMME YOURSELF AS LIVESTOCK IMPROVEMENT 31
++ Text units 32-32:
H--: Yes, that's right, in fact it was mine and it was the ... came up with a brand idea and the concept of the package service. It was a concept: I certainly had help from the likes of J-- M-- who refined the programme just about every year. And last year was the first year that it wasn't changed. I think we are going into the third year with virtually no change in the recommendation for protocol, but every year up until then there had been some fine tuning of it, and it was based on research that J-- had done, but the name has remained right through. 32
++
+++ ON-LINE DOCUMENT: P--
+++ Retrieval for this document: 2 units out of 431, = 0.46%
*MP: WHY IS THAT DO YOU THINK. 314
++ Text units 315-315:
J--: Human nature. Just the change. But certainly the Genomate programme is seen as very organised and well structured and I haven't any complaints from farmers in terms of failing dismally because of something wasn;t there at the right time or the technician didn't arrive. 315
*MP: WHAT WOULD YOU PUT THAT DOWN TO, WHY DOES IT APPEAR TO BE 317

++ Text units 318-318:
J-: Its probably a good combination of people working together because in that case you have the vets, Livestock Improvement, AB technicians and sales reps that are Livestock Improvement working together. If anything was going to fall down the Genomate programme would because the semen has to arrive Livestock Improvement despatched the ROs the areas as to have the technician there, the technician has to get there and the vet. 318

##
Cell (1 9)
(INTERSECT (10 1 6 14 1) (10 1 1 5 9))
This cell indexes no documents.
##
Cell (2 1)
(INTERSECT (10 1 6 14 2) (10 1 1 5 1))
This cell indexes no documents.
##
Cell (2 2)
(INTERSECT (10 1 6 14 2) (10 1 1 5 2))
This cell indexes no documents.
##
Cell (2 3)
(INTERSECT (10 1 6 14 2) (10 1 1 5 3))
++
+++ ON-LINE DOCUMENT: K--
+++ Retrieval for this document: 2 units out of 315, = 0.63%
*MSP: SO IT'S NOT JUST THE USE OF HORMONES ITS THE UNNATURAL STATUS OF 64
++ Text units 68-69:
The other perception which I think will get through, is that they perceive the seasonal calving system to be so economic that there can't be any other possibility of looking at any other system. What they haven't recognised is that the seasonal calving system may have extreme limitations in terms of exploiting genetic merit. And it has nothing to do with what we feed them, it has to do with there only being 365 days in the year. So the American system in particular (even more than in Europe) where they bring in all their feed, the Americans haven't twigged onto it, but they do it unintentionally. If for example the cows lactation curve looks like this 68
So what they are doing is lifting the peak without altering the rate of decline. If there is a line across say extra feed costs above maintenance that has to be paid for with milk, then all the time this is getting further out. The NZer's are looking at ways of reducing the rate of decline, but what the hell, what's the point of reducing the rate of decline when we've got no grass to feed them on? But in the US you can see what it does, and what it means is if you've got 365 days in the year, but you calve every day, then they have to have a 60 day dry period between 1 lactation and the next. Now you can see on a 365 day year they are in milk for 5 and they are dry for 1. If you went out to 18 months you are in milk for 8 and you are dry for 1. And if you are not producing calves for meat - and the NZ dairy industry is not - then much more energy is going into lactation than into pregnancy. So we are doing an extremely good job of increasing genetic merit, which is making the animal less natural, and not doing anything about altering our opportunities to utilise the genetics. And it may well be that as we keep on increasing the genetics we will need the US type system. The point is the ship has been kept afloat in a very high proportion of herds by using induction. So they've been able to reduce their replacement

rate down to 20% and maintain a seasonally concentrated calving, the average lactation length in NZ dairy cows is only 230 days. 69

```
################################################################################
### Cell (2 4)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 4))
## This cell indexes no documents.
################################################################################
### Cell (2 5)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 5))
## This cell indexes no documents.
################################################################################
### Cell (2 6)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 6))
## This cell indexes no documents.
################################################################################
### Cell (2 7)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 7))
## This cell indexes no documents.
################################################################################
### Cell (2 8)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 8))
## This cell indexes no documents.
################################################################################
### Cell (2 9)
### (INTERSECT (10 1 6 14 2) (10 1 1 5 9))
## This cell indexes no documents.
################################################################################
### Cell (3 1)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 1))
## This cell indexes no documents.
################################################################################
### Cell (3 2)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 2))
## This cell indexes no documents.
################################################################################
### Cell (3 3)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 3))
## This cell indexes no documents.
################################################################################
:
:
:
################################################################################
### Cell (3 7)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 7))
## This cell indexes no documents.
################################################################################
### Cell (3 8)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 8))
## This cell indexes no documents.
################################################################################
### Cell (3 9)
### (INTERSECT (10 1 6 14 3) (10 1 1 5 9))
## This cell indexes no documents.
```

Command files for extracting memos by code

A command file was used to extract memos by code and arrange these according to the hierarchical organisation of nodes with their definitions. The command file and a section of a report from the SAMM case study are presented below.

```
#####NUDIST Logfile started on date 2:31 pm, Jan 20, 1997.
Executing Command File :
"C:\\DATA\\PHD\\RESEARCH\\SAMM\\SAMPLAN\\COMMANDS\\MEMOS"
checking command : (MAKE-NODE-REPORT NIL WITH-NODE-TITLE? YES WITH-
DEFINITION? YES WITH-MEMOS? YES REPORT-MODE TO-SCREEN)
running command 1 of 1 : (MAKE-NODE-REPORT NIL WITH-NODE-TITLE? YES WITH-
DEFINITION? YES WITH-MEMOS? YES REPORT-MODE TO-SCREEN)
Command file run completed.
There were no errors.

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Mark S. Paine.

PROJECT: SAMPLAN, User Mark S Paine.

********************************************************************************
(1)             /problem domain
*** Definition:
relative clarity of mastitis issues requiring interventions
*** Memo:
1. identity emerges when the boundaries of a group or an individual's
perception of self are acknowledged [formally or informally].
Boundaries distinguish sharing from self-serving behaviour.
2. NZDE Aug 1992, p17: first mention of the discussion paper that proposes
an NZ approach to mging mastitis - a Woolford & Eden initiative -
invited NMAC to contribute.(Dec 92, econ figs & talk of proposal)
3. Why does practice of science (continuous inquiry) portray a role of
arbiter of truth? - essential to group identity; perceived expectation
from society/community; justification for involvement of RST in
programme?
4. Justifying the role of RST in Nw: penalities led to change, why RST? -
access to international Nw of RST (Smith; Panky; Ziv etc.), but for what
purpose; critical role; access to theories (ideas, propositions, ways of
problem solving), reduce uncertainty, confidence to act.
5. 5 pt plan an international programme (Joe, 1993) whereas SAMM plan
uses the idea of a NZ specific need (seasonal management) to pull
together diverse professionals in common cause.
6. NMAC critical structure to SAMM plan - also depends on SAMM Plan to
discharge functions.
7. identity generated from within (practice), but also from shared work (
without). When intent does not equate with achievement then a prompt
for shared work. Creates a dilemma at a second level - the ultimate
dependence is that of identity depending on partnering with others.
How does individual retain integrity when they derive a sense of
identity in their work with others?
8. a dilemma in work is the striving to identify the self in a programme
- normal tendency to seek equilibrium: harmonise action and intention,
whereas the development of practice requires the making of errors and
the reflection on competent performance - change is disturbing, even
more so when its origin is from outside the practice. Agencies muddle
```

through to gain identity (integrity) in new programmes - 'ownership' is
the measure of their success in locating themselves within programmes.
9. Agency refers to individuals, organisations and/or programmes
10. Programmes are like chinese dolls, often programmes within
programmes and part of larger programmes in terms of overall sector
intervention. Practices at interplay also make the boundaries of
intellectual property diffuse (or difficult to attribute to 1
individual) therefore where do agencies derive sense of identity from?
[eg. SAMM goals cf. SAMM actions]
:
****

(4 2 1) /managing mastitis/performance/tools
*** Definition:
artifacts used to perform work
*** Memo:
decision tools are embodied as fact sheets, booklets, and penality
schemes, BMSCC, ICSCC, etc.
2. Hook (1982) documents the emergence of ICSCC as part of herd testing
service - use in mastitis mgt.
3. July 96, p.10: herd test overview
4. BMSCC is a routine feedback tool; elected tools include ICSCC as an
addition to herd test data, bacterial spp identification, RMT or
conductivity monitoring, machine testing etc.
5. Tools contribute to a general potential to act. The access to tools
like computers, and the competence (a second order access) to use the
tool, influence the possibility processing capabilities of the agency.
6. Refinement of the penalty system as daily SCC resulted in improved
mgt control, and greater motivation to control mastitis, links with
legislation
7. 'For his identity as a tool-using creature is always the condition (
if only the condition) of his spiritual search of a transcendent
identity.' I&R. p.107.
****

(4 2 2) /managing mastitis/performance/tasks
*** Definition:
activities that comprise work
*** Memo:
actions include educating, researching and acting as watchdog.
****

(4 2 3) /managing mastitis/performance/knowledge
*** Definition:
beliefs that influence performance: practical & conceptual
*** Memo:
SAMM is mastitis mgt focussed - content is practical knowledge, claims
derived from scientific knowledge (they make the distinction, see Joe
93; NZDE, May 96, p43). Requires science to legimate the practical
claims of practitioners.
2. A sequence of overseas expertise brought in to frame the NZ approach
to mastitis mgt - Bramley; Smith Pankey - constructing a decision
context; framework; knowledge base; system of delivery
****

:
:
:
:
:

Samenvatting

Na de verkiezingsoverwinning van Labour in 1984 hebben economische hervormingen in Nieuw Zeeland geleid tot een snelle en grootschalige vermindering van landbouwsubsidies. Binnen een periode van tien jaar werden subsidies op kunstmest en maatregelen ter ondersteuning van prijzen geschrapt, de agrarische voorlichtingsdienst geprivatiseerd, en werden de onderzoeksorganisaties geherstructureerd in de richting van concurrentie. De Nieuw Zeelandse overheid en de productiesectoren hadden als beleid het gezamenlijk investeren in onderzoek, onder andere gefinancierd door de opbrengsten van dat onderzoek zelf. Deze veranderingen hebben geleid tot debatten tussen het wetenschapsbeleid en onderzoeksmanagers over de manier waarop onderzoeksinstellingen en commerciële organisaties konden samenwerken in onderzoeks- en ontwikkelingsprogramma's. Dit proefschrift wil inzicht bieden in de huidige verbindingsactiviteiten in de Nieuw-Zeelandse melkveehouderij sector en daarmee het wetenschapsbeleid en de onderzoeksmanagers, die in de sector opereren, te helpen om hun verbindingen met commerciële organisaties te verbeteren. Meer specifiek: hoe verbinden organisaties en actoren hun activiteiten om technologie te ontwikkelen voor de Nieuw Zeelandse melkveehouderij en hoe kan begrip van deze verbindingsactiviteiten het werk van technologiemanagers in de melkveehouderij sector versterken? De melkveehouderijsector werd geselecteerd omdat in deze context samenwerking in technologie management met een redelijk mate van waarschijnlijkheid kan worden waargenomen.

Een case-studie onderzoeksopzet is gebruikt om drie programma's te onderzoeken waarbij sprake was van enige vorm van samenwerking in onderzoek en ontwikkeling tussen overheidsonderzoek en commerciële organisaties. Het gaat om de volgende programma's: de ontwikkeling en marketing van een apparaat (CIDR); de ontwikkeling van een sectorbreed systeem van kwaliteitsmanagement (SAMM) ; de ontwikkeling van management methoden voor natuurlijke hulpbronnen in de landbouw (SSGP). Ieder programma is bestudeerd met behulp de Glaseriaanse school van de Grounded Theory methode. Deze school benadrukt het naar voren komen van theoretische perspectieven waarbij wordt gebruik gemaakt van de constante vergelijkingsmethode van gegevensverzameling en vergelijking. Een procedure voor het onderzoeken en vergelijken van veldgegevens heeft de auteur gebruikt om een theorie te ontwikkelen en te vergelijken met andere perspectieven in de literatuur.

Er bestaat een uitgebreide organisatietheoretische literatuur over samenwerking en technologie management. Deze literatuur is bestudeerd met het oog op de landbouwcontext. Twee bijzonder leerzame perspectieven werden geïdentificeerd: Agricultural Knowledge Systems (AKS); en het Interplay Model. Het AKS perspectief heeft de auteur gevoelig gemaakt voor een constructivistische *'theatres of innovation'* visie waarbij actoren en organisaties onderhandelen en hun kennis sociaal construeren met betrekking tot hun probleemcontext. Het Interplay Model benadrukt dat het naar

voren komen van eigenschappen van samenwerkingsrelaties tussen onderzoek en commerciële entiteiten primair een functie is van activiteiten die worden uitgevoerd in praktijken. In het model wordt een gespecialiseerde omschrijving van het begrip 'praktijk' gebruikt, waarbij praktijk een manier van doen is: indien er naar wordt gevraagd, zullen actoren hun activiteiten verklaren door te verwijzen naar 'de manier waarop de dingen hier gedaan worden'. Praktijken die opereren in 'theatres of innovation' worden intentioneel door actoren uitgevoerd. Bovenstaande perspectieven werden door de auteur gecombineerd om gegevens uit de case-studies, opgevat als activiteiten en uitgevoerd in 'theatres of innovation', te onderzoeken.

De CIDR (Controlled Intravaginal Drug Release) case-studie documenteert in vier chronologische fasen het ontstaan van een synchroniseringstechnologie om de voortplanting van koeien in de melkveehouderij te beheersen. Vroege ontwikkelingspogingen hadden betrekking op het ontwikkelen van een apparaat, terwijl latere activiteiten gericht waren op het maken van behandelingsprotocollen. De gelijkschakeling van de activiteiten die werden uitgevoerd door de actoren in het programma, werd op verschillende manieren bereikt. In de loop van het programma verkregen de actoren inzicht in de praktijken die werden uitgevoerd door de andere actoren. Als deze praktijken door het leveren van professionele diensten in elkaar werden geschoven, hadden de actoren in het programma wederzijds vertrouwen en respect nodig om samen te kunnen werken. De intellectuele eigendomsrechten die uit het programma voortkwamen, werden periodiek bestudeerd en heronderhandeld onder verwijzing naar het begrip 'familie' of het begrip 'club' waarvan actoren uit verschillende organisaties lid waren. De identiteit van de club verschafte een mogelijkheid om innovatieve strategieën te maken voor het uitvoeren van nieuwe ontwikkelings- en marketingactiviteiten. In de case-studie wordt de CIDR beschreven als een bijdrage aan het ontstaan van een praktijk: het apparaat vormde een onderdeel van een expanderend ontwikkelingsbereik dat verschillende synchroniserings apparaten, protocollen en begrippen uit de melkveehouderij omvatte. Ontwerpers gebruikten deze apparaten en protocollen om de regels van de synchronisering vorm te geven. De synchroniseringspraktijk maakte het voor de ontwerpers mogelijk om grenzen te doorbreken die anders zouden zijn opgelegd door organisaties die een onafhankelijke claim op de intellectuele eigendomsrechten hadden willen leggen. De continuïteit van de dingen die naar voren zijn komen in de CIDR studie, werd door de actoren uitgewerkt in een proces van 'zich er doorheen slaan'. Door reflectie op hun activiteiten leerden de actoren van hun fouten en konden zij hun intenties aanpassen.

De SAMM (Seasonal Approach to Managing Mastitis) case studie onderzocht hoe een sectorbrede interventie, uitgevoerd onder een beleid van vrije markt politiek, heeft gewerkt ten aanzien het beheer van mastitis in de nationale veestapel. Een serie ingrepen was al uitgevoerd voor de introductie van SAMM. Deze vroege ingrepen hebben de weg bereid voor de SAMM, omdat actoren in de sector, afkomstig uit verschillende praktijken, ingespeeld raakten op de mastitisproblemen en instrumenten en routines

hadden ontwikkeld om deze problemen aan te kunnen. Maar geen enkele specifieke organisatie of beroepsgroep claimde het beheer van mastitis als haar werkdomein. Daardoor was de weg vrij voor het formeren van een comité (NMAC) dat als doelstelling had om mastitisproblemen op te lossen door interactieve activiteiten te bevorderen. De NMAC verschafte een interface voor praktijken die ingrepen ontwikkelden en gebruikte de SAMM tevens om de regels van het beheer van mastitis vorm te geven, waardoor boeren en anderen in staat werden gesteld op een bedrijfsspecifieke manier om te gaan met mastitis. De activiteiten van de NMAC zelf vormden een soort praktijk, die als bemiddelend werd beschreven. De bemiddelende praktijk van de MNAC maakte strategieën om samenwerking tussen organisaties en actoren te bevorderen. Het leerproces van deze organisaties en actoren bestond uit reflectie over hun gemaakte fouten. Tevens bestond het leerproces uit het combineren van hun ervaringen in het comité, dat zelf institutionele steun kreeg. De melkproductiebedrijven, die ten behoeve van de export melk in verschillende produkten omzetten, waren lid van de NMAC en speelden een steeds belangrijkere rol in het oplossen van het vraagstuk van het beheer van mastitis. De melkproductiebedrijven gebruikten twee instrumenten om het mastitisniveau te verlagen: een prijsbeleid voor onbewerkte melk en het verschaffen van informatie aan boeren. In het geval van de SAMM kwamen de problemen voort uit de praktijk. Ook hier kunnen de activiteiten van actoren beschreven worden als zich er doorheen slaan in de richting van een verbeterd beheer van mastitis, waarbij veranderingen in interventieprogramma's tot stand kwamen door reflectie over gemaakte fouten. De bemiddelende praktijk werkte in de richting van de facilitering van verbeterde leercondities op sectorniveau voor die actoren die werken aan het beheer van mastitis.

De laatste case studie onderzocht een Sustainability Study Group Programm (SSGP). In dit programma werd door middel van een participatieve aanpak onder boeren, milieudeskundigen en onderzoekers geprobeerd om op de boerderij het beheer van enerzijds natuurlijke hulpbronnen en anderzijds productiedoelen onderling af te stemmen. De deelnemers in SSGP werden in het begin aangemoedigd om mee te doen door de twee programmaleiders die het programma hadden ontwikkeld. In een periode van 18 maanden ontwikkelde het programma landbouwmethoden die op de boerderij de afstemming bevorderen tussen de doelen van het beheer van natuurlijke hulpbronnen en de productie, zij het met een ruime mate aan onzekerheid over het doel van de collectieve activiteit en de voorwaarden voor collectieve activiteit. Een crisis in het conflict tussen milieu- en landbouwproductiedoelen resulteerde in een uitgebreide inspanning om de doelen te herdefiniëren met de behoeften van de boeren als uitgangspunt, maar binnen de behoeften van de milieudeskundigen en de onderzoekers. De activiteiten die het doel en de werkplannen van het programma herdefinieerden, introduceerden een nieuwe stijl van interactief werk, waarbij boeren, milieudeskundigen en onderzoekers elkaars werk aanbevolen aan derden buiten het programma. De manier waarop actoren het programma weergaven aan deze derden, vormde een onderdeel van het tot stand komen van een bredere vorm van integriteit in het programma. Deze

integriteit maakte meer ontwikkelde vormen van reflectie op activiteiten mogelijk, waarbij de actoren in het programma elkaars werk beoordeelden en zich positioneerden ten opzichte van elkaar.

De beleidmakers die voorstanders waren van de hervormingen in Nieuw Zeeland waren onder andere gericht op het versterken van de relatie tussen wetenschap en commerciële instellingen. Dit proefschrift heeft niet de bedoeling om de genoemde hervormingen te evalueren, maar wil nieuwe mogelijkheden voor samenwerking in een vrije-marktomgeving identificeren. Aanbevelingen aan actoren en organisaties in de context van de vrije-marktsector zijn beperkt tot situaties die identiek zijn aan de melkveehouderij in Nieuw Zeeland, waar een verticaal geïntegreerd marktkanaal is verbonden met sectorprogramma's voor jonge beginnende boeren en met een gecoördineerde informatievoorziening voor boeren. Ondanks deze nadere kwalificatie lijkt het erop dat een waardering voor de manier waarop actoren samenwerken, programmamanagers kan helpen bij innovatie en het management van technologie in 'theatres of innovation'. Deze waardering kan vooral helpen bij het oplossen van de vraag hoe deze activiteiten van programmamanagers worden gecoördineerd en ontstaan als verfijnde strategieën voor het aanpakken van problemen en onderwerpen die zelf voortkomen uit collectief werk. Het proefschrift eindigt met de constatering dat er een behoefte is aan een verdere ontwikkeling van methodologieën die de mogelijkheden van de onderzoeker om activiteiten te bestuderen in participatieve werkcontexten zullen verbeteren.

Curriculum Vitae

Mark Paine was born in Tauranga, New Zealand in 1958. He, his wife Karenza, and their boys Lachlan and Fraser live in Hamilton, New Zealand where Mark is employed by AgResearch as an Extension Researcher.

Mark completed a batchelor degree in Horticultural Science (Lincoln University) with an emphasis on the production and marketing of horticultural products. After completing his degree, Mark was employed by the then MAF Advisory Services Division as an Horticultural Advisory Officer extending technical information to growers in the Hawkes Bay, New Zealand. While working with fruitgrowers, Mark developed a particular interest in issues of farm management, particularly the decision making behaviour of growers and the role of information support services. To pursue this interest further, Mark took a teaching and research position at Massey University in the then Department of Farm Management and Agricultural Economics. His research activities at Massey involved the development of a farm monitoring programme with growers in the Wanganui area, where he later moved to teach and consult growers in the region.

Following the privatisation of government extension services, Mark returned to the MAF as a senior consultant, leading a team of consultants in the Tauranga area during the formative years of privatisation of the extension services (1987 to 1991). During this time Mark also completed his Masters degree on the development of management support to farmers using fee paying services. His dissertation laid particular stress on the importance of participatory learning experiences emerging from the interaction of farmers and consultants using formal monitoring programmes to assist farm decision making.

Mark's combined experience in research and consultancy provided contract opportunities, serving Government Departments and the recently formed Crown Research Institutes with studies concerned with the management of technology under conditions fostered by free market policies. The insights and issues raised during this contract work evolved towards the contracting of Prof. Niels Röling to New Zealand in 1992. The work at Wageningen Agricultural University on Agricultural Knowledge Systems aroused considerable interest among a group in New Zealand, and this combined with the rapid and extensive economic reforms experienced in New Zealand opened a window of opportunity for Mark to study as a PhD candidate under Prof. Röling from 1994 to 1997. Mark has focused on the dairy sector in recent years, though he has recently completed an extensive study of the learning experiences emerging among members of sheep and beef Farm Monitoring groups.