

Learning and research for sustainable agro-ecosystems by both farmers and scientists.

Final report

November 2005

Dr Fergus Lyon¹, Dr. Sarah Clarke², Dr. Frances Harris³, Prof. Martin Wolfe², Dr David Gibbon

¹ Centre for Enterprise and Economic Development Research, Middlesex University.

² Elm Farm Research Centre.

³ School of Earth Science and Geography, University of Kingston

Contents

Summary	3
Background	6
Part 1: Approaches for research on agro-ecosystems	12
1.1 Introduction	12
1.2 Research approaches in the case study projects	12
1.3 Bringing scientific data from different scales together	14
1.4 Conclusion	17
Part 2: Farmer learning and research	18
2.1 Introduction	18
2.2 The epistemology of farmers' research	18
2.3 Learning with advisors	21
2.4 Learning through networking	22
2.5 Types of farmers and motivations	23
2.6 Conclusion	24
Part 3: Collaboration and interdisciplinary scientific teams	25
3.1 Introduction	25
3.2 Motivations to be interdisciplinary	26
3.3 Types of scientists in case study projects	29
3.4 Challenge of bringing different disciplinary contributions together	33
3.5 Inter-organisational interdisciplinary relationships	37
3.6 Conclusions	42
Part 4: Scientist involvement with farmers in interdisciplinary agro-ecosystems research	44
4.1 Introduction	44
4.2 Farmers involved in the design of the research question	45
4.3 Farmers decide on manipulations	47
4.4 Farmer involvement in evaluation	47
4.5 Researchers examine farmers' practices	49
4.6 Recruiting farmers	49
4.7 Bridging the farmer-scientist gaps	51
4.8 Statistical rigour and participatory research	54
4.9 Conclusion	57
Part 5: Overall Conclusions	58
Appendix I Methodology	60
Appendix II Bibliography	63
Appendix III Details of case studies	70

Summary

This project is based on the premise that knowledge production on rural environmental issues requires a collaborative systems approach that involves a range of stakeholders (especially farmers) and crosses disciplinary boundaries. We use the term agro-ecosystems to refer to the relationships of humans and natural resources in the production of agricultural goods and environmental services. However, the complexity and diversity of such agro-ecosystems presents challenges to researchers who are conducting research. This requires greater understanding amongst scientists and between scientists and farmers, recognising each other's strengths and weaknesses, and finding ways of working together.

This report explores how researchers can examine whole systems, how farmers learn about their systems, how researchers can carry out interdisciplinary research, and how farmers and researchers can collaborate. This is done by examining 10 case study research projects with qualitative interviews of researchers and farmers involved.

How farmers innovate, learn and develop farming systems

Farmer learning was found to be carried out through reflection, networking and with advisors, and innovation generally depended on the character of the individual. Farmers were found to be involved predominantly in incremental changes such as trying new varieties or equipment and often experiments occurred from chance or unintentionally.

Our findings suggest that farmers manage their farms by adopting complex 'system level' or holistic thinking to link important agronomic, economic and social decisions. Farmers may have a different concept of 'check' to the researchers with validation coming from inter as well as intra-farm replication. In this farmer networking is an important part of their learning processes, as are the roles of advisors who can compare treatments on different farms. Farmer research was also found to be carried out subconsciously and form part of the farmers' tacit knowledge.

Collaboration and interdisciplinary teams

Interdisciplinary and participatory research, by their very nature, bring together people from varying backgrounds, disciplines, skills and perspectives. Most cases studies involved researchers from at least two institutions. The study showed that the goals of researchers often differed. Commercial technology company scientists will want to have ideas that can be converted into profitable businesses for customers. Pressure group scientists want to disseminate research rapidly via membership newsletters or popular press. More academic researchers may want results to be more rigorously statistically tested so that they can be disseminated through publication in peer-refereed journals. There are also contract researchers who have specific funding pressures and tight deadlines in which to complete particular projects.

In each of the cases, issues of co-operation were based on interpersonal trust. Trust was found to be shaped by issues of information on others, sanctions and common norms. The information on others from existing relationships, from intermediaries, or is built up through working together. Trust based relationships appeared to be instinctive at times with people habitually trusting others as they have sanctions over them (and information on their reputation) that might not be drawn on consciously. This was evident from the hesitation in replies to questions and the difficulty in explaining the nature of trust relations. From this we can conclude that trust does not

necessarily have to be a pure calculation but also includes elements of habits and routines.

Scientist involvement with farmers in interdisciplinary agro-ecosystems research

The case study projects demonstrated a range of different types of interaction with farmers. Farmers operate at the whole farm system level, not focused on one particular research topic. Therefore researchers needed to show respect for farmers' commitments, take into consideration the demands the project is making on normal farming practices, and the timing of research work in relation to farmers' work calendar. The issue of trust was again raised as an important issue allowing co-operation. A key role was played by individuals who acted as boundary spanners with an understanding of the needs of both farmers and scientists, bringing disparate groups together and, ensuring clear communication.

Farmer participatory research was not found to be cheaper or quicker. Rather than investing in equipment and experiments, it required a lot of staff time to develop relationships with farmers and other researchers. Several of the projects stated that they were under-costed. The difficulties of ensuring statistical rigour when working with farmers was mentioned by four of the cases. Specific statistical advice was found to be used to identify the number of farms required to provide statistically robust results, as well as guidance on experimental layout. Alongside their involvement in a research project, farmers are still running a business and may not prioritise research related treatments, or inadvertently change treatments. Researchers with experience of these constraints made allowances for the loss of experimental sites in the original statistical design of their work.

Conclusions

The findings present insights into the process of inter-disciplinarity and trans-disciplinarity. The study of farmers own research found that while formal science has to ignore local complexity in order to generate a technology for a wide recommendation domain, farmers' research is based on local complexity, with farmers having to cope with many conflicting demands. Their knowledge production may be conscious or more habitual and based on building up tacit knowledge. It also identified the key role for networking amongst other farmers and discussions with advisers in fuelling this learning.

The process of carrying out interdisciplinary research is shown to be dependent on a range of relationships that are shaped by both power and trust. There are challenges of bringing disciplines together, although funders were found to be important factors in encouraging people to work across the disciplinary boundaries. There are other boundaries observed in terms of the different types of researchers and their institutions.

The issue of trust was also central to these relationships with people drawing on existing relationships, building trust up through working relationships or using intermediaries who are known to all parties and act as guarantors. These relations are also underpinned by a set of norms concerning reciprocity, what is considered honest behaviour, and use of each other's knowledge. Trust is based on having information on the parties concerning their reliability and the expectation that they will act as expected. It is also based on having potential sanctions over them, either through contractual controls, but, most importantly for the teams examined, in terms of peer pressure.

The interaction with farmers results in a range of other relationships. There is a need for farmers to trust that the researchers will work as expected and for researches to

trust that farmers will co-operate. The project found that there are degrees of farmer participation with differences in the extent to which researchers hand over power to the farmer in terms of the design and evaluation of the experiment or research. Relinquishing power was found to be in conflict with the need to have statistically rigorous research as farmers may not ensure that treatments remain unchanged through the research. Where there is more farmer involvement, the interaction with researchers is found to be more informal with feedback on technology or processes that may not be published but feeds into the 'tacit knowledge' being acquired by researchers. This form of research was found to be more common amongst private sector researchers.

The specific lessons coming out of this research include:

- The need to ensure good communication and team building between researchers and with farmers. This takes time and is often not costed into research proposal. Short term funding also limits these relationships.
- Farmers' own research and holistic assessments of technologies and practices can make a vital contribution to knowledge production although its approach can be very different to scientific method
- Farmers and different types of scientists have differing agendas that have to be negotiated.
- The ability of some researchers to participate in interdisciplinary participatory research can be limited by institutional pressures (such as the need to publish in academic journals) unless there are alternative incentives.
- Boundary spanners who have an understanding of the needs of scientists and farmers may be required to facilitate the development of relationships.
- For statistical research, the selection of sites should take into consideration the likely loss of some sites from the research due to the uncertainties of farming. Statistical advice should be sought from the start.

Background

This project is based on the premise that knowledge production on rural environmental issues requires a collaborative systems approach that involves a range of stakeholders (especially farmers) and crosses disciplinary boundaries. This report explores how researchers can examine whole systems, how farmers learn about their systems, how researchers can carry out interdisciplinary research, and how farmers and researchers can collaborate. This is done by examining 10 case study research projects.

Such approaches to knowledge production require greater understanding amongst scientists and between scientists and farmers, recognising each other's strengths and weaknesses, and finding ways of working together. This interdisciplinary subject is examined by a team of social, environmental and biological researchers, examining ten cases of farmer researcher collaboration with the aim of identifying good practice in interdisciplinary research on agro ecosystems in UK agriculture.

We use the term agro-ecosystems to refer to the relationships of humans and natural resources in the production of agricultural goods and environmental services. However, the complexity and diversity of such agro-ecosystems presents challenges to researchers who are conducting research. Research into agro-ecosystems can combine research from traditional agricultural disciplines (animal science, soil science, plant pathology, agronomy, agricultural economics) with wider ecological issues, long-term environmental implications, and social and economic issues (Checkland, 1999). Furthermore, sharing the results of scientific research with farmers requires a greater understanding of how farmers learn and develop farming systems that are best suited for their land and the context of their farming enterprise.

A systems perspective to research offers many advantages (Nissani, 1997), and there have been many papers arguing in favour of integrating social and biological research (eg Berkes and Folkes, 1998). These include an improved relevance of results to beneficiaries and greater uptake of results by end users. However, such approaches also present challenges, such as finding a common language and methodological approaches; integrating the results of social and biological research; and effectively integrating the results of research carried out at different scales, so that scientific advances at the level of the genome, plant, field and ecosystem are integrated together and with greatest relevance to the farming system and wider food production system. Furthermore, a systems perspective requires research to consider the needs of all actors, including farmers, agriculture-related businesses, scientists and social scientists, and also the relationships between all actors.

There are limitations to systems approaches when compared to more 'reductionist' research that examines specific parts of systems independently of other variables. The strength of a 'reductionist' scientific method is that it relates to concepts, practices and technology that are based on tried and tested theories leading to universally applicable results, or results related to a specific set of conditions. Knowledge is generated through rigorous procedures that attempt to control variables in order to get quantitative results with a high degree of precision for statistical analysis. Robust results can be used to convince others, make confident recommendations and can also be extrapolated to different contexts. The results are tested to ensure potential general applicability but may not be ideally suited to particular agro-ecosystems.

At the same time, farmers and other land users are doing their own research to tailor their farming to their specific agro-ecosystem. This research may be carried out in a less rigorous manner, often through observing their experiences. They may not refer to this as research or experimentation, but it is an important way of learning and generating 'anecdotal' evidence.

Scientific research relies on the use of averages and a probabilistic outcome while farmers want to know what happens under different conditions and make 'qualitative plausible assessments' (Suppe, 1987). The diversity between and within farms means that research scientists cannot specify the work for specialised recommendation domains. Farmers develop ideas for a particular farm and not necessarily for extrapolation.

The challenge of agro-ecosystems research is to find ways of combining scientific and farmers' own research and learning. Therefore agro-ecosystems research needs to be tackled from a wider perspective than mono-disciplinary approaches can achieve. This report draws on a framework that makes a distinction of multi-, inter- and trans-disciplinary research. While these terms have been debated extensively, for the purpose of this report the following definitions are used:

Disciplinary research is research which focuses on a single disciplinary perspective.

Multidisciplinary research is research which tackles research issues from several disciplines. Each discipline reaches its own conclusion, and there is no attempt to integrate the research results by the multidisciplinary research team, rather, it is up to each reader of the disciplinary reports to link and integrate the results as they see fit.

Interdisciplinary research is research carried out between the academic disciplines, at the boundaries of existing disciplinary knowledge, and in the interstices between disciplines. The aim of interdisciplinary research is to develop new knowledge and new approaches to research and thinking based on the integration and further development of ideas from individual disciplines. Such cross-fertilisation between the disciplines can ultimately develop new disciplines (e.g. biochemistry), or new theories.

Transdisciplinary research goes beyond academic disciplines to include other, non-academic groups, such as farmers, other businesses, government and policy makers, and the public. In this way, it is participatory, although the participation can be with producers of research, consumers of research, or both. It can also focus on the links between research, decision makers, and the development of policy from research outcomes.

It is fair to say that many projects may combine elements of these three distinctions. As any or all of these approaches may be used at different times and for different purposes. Research, such as this RELU project, may be both interdisciplinary and transdisciplinary, if it involves a range of stakeholders and disciplines who seek to work in an integrated manner. Multidisciplinary research may become more interdisciplinary if the research group chooses to work more closely together and exchange ideas and insights.

The question of language is also relevant to interdisciplinary research. Disciplines use terms in particular ways, and have created languages in which to discuss their findings. An initial challenge to interdisciplinary research can be to find a common language in which to discuss research issues, and how they might be approached (Oughton and Bracken, 2005). The challenge at the beginning of any research

process is to develop a common conceptual framework that all “types of scientists” can live with and agree to.

The process of reviewing, funding, and evaluating research poses a minefield of problems for interdisciplinary and transdisciplinary research. Are more applied research aims as widely respected as pure research? It is widely believed that interdisciplinary journals are not valued as highly as specialist journals, so what about publication and dissemination of results? What about the career progression of individuals who take the intellectual challenge to engage with other disciplines, but may find they are penalised in terms of promotion within their own original discipline? The Research Assessment Exercise and current publishing systems are seen as stifling creativity and innovation in cross-boundary research and discussion because the greatest weighting is given to single authored papers in “blue chip” journals and everything else is given a lower rating.

Based on these debates, the key research objectives identified for this study are:

How do research scientists carry out whole farm agro-ecosystems research?

- What research methods are most suitable for research on agro-ecosystems?
- How can scientific data from different scales (e.g. test-tube, plot, ecological surveys) be brought together to identify more general trends at the system level?

How do organic farmers innovate, learn and develop farming systems that are best suited for their land and the context of their farming enterprise?

- How do farmers balance the multiple functions and objectives of their farming enterprise (food production, ecological services, profit generation etc)?
- What are the forms of experiential learning, farmers’ own research and adaptation to local agro-ecosystems?

How do researchers collaborate in interdisciplinary teams?

- How can social science be integrated with other scientific disciplines for the development of sustainable agro-ecological systems?
- How have projects managed to overcome separate disciplinary traditions of information gathering, research methodologies and language in order to work together to achieve results?

How can farmers and researchers collaborate ?

- How can agricultural scientists implement statistically rigorous methodologies within the diversity and complexity of on-farm farmer participatory research?
- What factors constrain collaboration between farmers and researchers, and conversely what factors are considered important in successful cases of collaboration?

These questions are examined by using ten detailed case studies, interviewing researchers, farmers, policy makers and advisors . The cases are summarised below.

1. Home Farm Organic Study

This project aimed to compare organic and conventional farming by examining agronomic, economic and ecological factors. This was done by: establishing the efficiency of nutrient cycles; assessing vegetation changes in field margins and grassland; examining the impact of different farming systems on certain fauna (e.g. butterflies and small mammals); and carrying out a full socio-economic audit of a developing organic farm. The project concluded that although nutrient cycles were

relatively efficient and there were biodiversity and social gains in farming organically, the cost of transition to organic agriculture was not covered by the current conversion support payments.

2. WildCRU-Chichester Coastal Plain Sustainable Farming Partnership

The main aim of this project was to establish a demonstration area of the best practice for sustainable farming and biodiversity enhancement, where land managers and practitioners could experience sympathetic management first hand. The project highlighted the problem of diffuse pollution, the benefits of buffering watercourses and demonstrated actions for enhancing biodiversity. It also examined the best practice and restoration options that could enhance habitats on farmland and improve the connectivity of the floodplain with its backwaters, ponds, wet grassland, marshes, reedbeds and ditch network. The effectiveness of these various options were tested through a series of comparative experiments designed to measure changes in habitat and abundance of key biodiversity indicator species (such as the water vole) (Strachan & Holmes-Ling, 2003).

3. Sustainable Arable Farming For an Improved Environment – SAFFIE – enhancing biodiversity

The objective of this project is 'to enhance farmland biodiversity and develop more sustainable farming by integrating novel management approaches in the crop and uncropped margins'. The project is split into 3 main experiments. Experiment 1 is concerned with the management of the crop, looking at how crop architecture affects birds and how crop protection inputs can be used to maximise biodiversity. Experiment 2 examines how different grass seed mixtures sown in the margin and managed under three options affect biodiversity. The third experiment assesses the integrated effects of using four of the best crop and margin management strategies in a factorial design on bird populations, biodiversity and agronomy. A cost-benefit analysis will be carried out on the best practices. The project is ongoing.

4. Evaluation of the pilot Entry Level scheme for DEFRA

This project was a pilot of a new agri-environmental scheme which aimed to encourage farmers to deliver environmental management in the areas of biodiversity, landscape, the historic environment and diffuse pollution. The Entry Level Scheme (ELS) was tested in four areas of England, representing four different farming types (grassland, arable, upland, mixed) and was open to all farmers in those areas. Participating farmers developed a plan of the management they would carry out, made up of a number of options, each worth a certain number of points. Research was then conducted into the likely environmental impact of the scheme and information was gathered on the uptake, acceptability and administration of the scheme. It was concluded that the pilot was a success and the ELS had a high level of support and had the potential to deliver substantial environmental benefits.

5. Nickersons plant breeders/Brown & Co and the Buster Club

Nickersons is a plant breeding company, with a specific interest in wheat breeding. As part of their work, they have involved farm consultants (Brown and Co) and a group of farmers, the Buster Club, who give them feedback on the criteria farmers are looking for and share their opinions on different varieties being developed. The group meet informally several times a year, with farm walks, visits to trial sites and discussions in the pub. Farmers can also try varieties early and be involved in seed growing of new varieties. The group is also involved in visits to buyers and users of wheat.

6. Integrated control of wheat blossom midge: Variety choice, use of pheromone traps and treatment thresholds.

The objective of this project was to develop a system of integrated control of orange wheat blossom midge (OWBM). This was done by determining vulnerable and tolerant varieties and developing a trapping system to assess risk early on. Some varieties were shown to be resistant and gave a yield advantage of at least 2t/ha when heavily challenged by the pest. As well as resistance, some varieties were found to be more vulnerable to damage than others. Susceptibility was shown to depend on several genes and a mechanism for testing these traits was developed. Pheromone traps were developed through to a marketable product and the numbers of males caught were correlated to the level of egg-laying by females. However, risk of migration from other fields and suitability of weather for egg laying varied among sites. A further project has been commissioned.

7. Unilever and Birdseye Sustainable Farming Partnership

This project is funded by Unilever's sustainable agriculture programme and involves research on the farms of pea growers and is also carried out on Unilever's Colworth estate in Bedfordshire by in-house researchers and external partners. There are three main objectives to this project. The first is to measure the long-term impact of current farm practice (Normal Agricultural Practice – NAP) compared to an extreme alternative (Extreme Agricultural Practice – EAP). Both EAP and NAP are flexible and change with accumulated knowledge. The variables tested through NAP and EAP included rotation, pesticides, fertilisers, crop timing (winter vs. spring) and margin management. The second objective is to assess and improve biodiversity and the third to understand the economic consequences and implications of the EAPs through the development of a cost model. The project is ongoing.

8. Nitrates - Improving N use and performance of arable crops on organic arable farms using an expert group approach

The objective of this project was to enhance the productivity of organic arable systems by identifying changes that could be made to increase nitrogen availability and decrease nitrogen losses from the system using an 'Expert group' approach. This was done by looking at 9 case study farms and calculating nutrient budgets for these farms. These were then studied by experts in organic farming, nutrient management and crop physiology along with information taken from the literature, who made recommendations on strategies that could improve the nitrogen efficiency of organic farms. They concluded that small improvements in efficiency of nitrogen use in organic systems could lead to large improvements in output. These messages were disseminated to the organic farming community through presentations and a booklet.

9. Animal Welfare -Qualitative assessment of behaviour as a method for the integration of welfare measurements.

Previous SAC research developed a method of assessing animal behavioural expressions which had the potential to be a tool for integrating different scientific approaches to animal welfare. This involved 'free choice profiling' (FCP), which gives observers freedom to choose their own descriptors of welfare, which is then analysed with generalised Procrustes analysis (GPA), a multivariate statistical technique. The aim of this project was to 'develop the potential of the FCP/GPA methods to integrate different types of biological data relevant to animal welfare, in a range of studies'. Here we refer to one of these studies, whose objective was to apply the FCP/GPA approach to on-farm welfare assessments. Vets were introduced to the FCP method and then taken to a range of pig farms where the methods of examining welfare of the pigs was assessed.

10. Biosecurity Constraints to uptake of adequate biosecurity on UK cattle and sheep farms, with special reference to zoonotic diseases

The main objective of this study was to identify issues considered to be key constraints and incentives to uptake of better biosecurity measures on cattle and sheep farms by veterinarians, members of livestock auxiliary industries (e.g. markets, hauliers), other stakeholders (e.g. levy bodies, tourist industry) and the farmers themselves. This was done by conducting farmer focus groups including studies of farmer attitudes based on the Theory of Reasoned Action (TORA), and surveys of the other groups mentioned above. The project also looked at costs and benefits of implementing biosecurity measures and constraints to the uptake and adherence to animal health schemes offering accreditation for disease freedom or monitoring. The project concluded that the different stakeholders did little to collaborate with biosecurity measures and often had negative perceptions of each others' contribution to the common cause of biosecurity.

Part 1: Approaches for research on agro-ecosystems

1.1 Introduction

The term agro-ecosystems has been debated, but is widely accepted that it relates to relationships between humans and biological or natural resources, for the purpose of producing food, non food goods and environmental services (Ison, 2002). While the term has been used as the underpinning of 'alternative agriculture (Altieri, 1987), it is used in this project to include the wide range of types of agriculture and their impact on the environment, while including the human relationships and socio-economic aspects that are involved. In this section, we examine how researchers can carry out whole farm agro-ecosystems approach by looking at some of the methods and also the issues of scales of research.

Agro-ecosystems research is a diverse field although there are common threads in terms of multi-disciplinarity and consultation with farmers, researchers and others at the beginning. On-farm trials are common with varying levels of farmer participation and an iterative process whereby as the system is better understood, experiments can be improved (Conway, 1985, Conway, 1987, Anderson and Hardaker, 1992, Sands, 1986, Bawden, 1991, Gibbon, 2002).

While much of this work has taken place in developing countries, there has been work in this area in Australia, USA and Europe. Long-term agro-ecological systems studies have been running in the American states of Iowa (Delate, 2002) and North Carolina (Mueller *et al.*, 2002) looking at soil characteristics, weed populations, diseases, insects, plant growth and development and the economic performance of different farming systems. These studies are multidisciplinary and carried out on experimental farms, although other farmers are involved through focus groups which direct the research (Delate, 2002). A similar long-term project in Germany has also been reported (Schroder *et al.*, 2002). However, the most well-known example of agro-ecosystems research was at Hawkesbury, Australia (now part of the University of Western Sydney) which had an emphasis of learning or researching systems (Bawden, 1992).

1.2 Research approaches in the case study projects

The project specifically chose case studies with different aspects of agro-ecological research with elements of crossing disciplines and farmer involvement. Since agro-ecosystems are systems that produce both food and other socially beneficial goods and environmental services, projects usually required the involvement of scientists from several different disciplines and this also usually meant different institutions. Most of the cases studied here involved collaborators from at least two, and usually more, institutions (Table 1.1). For example, the SAFFIE project involves scientists from 10 institutions and many disciplines including ecologists, weed scientists, entomologists and ornithologists.

Most of those organisations involved in these cases have a tradition of being involved in transdisciplinary research, particularly for organisations such as WildCRU and ADAS that have a practical mission as a main objective and so are drawn to these types of research projects. For commercial companies, the reasons behind collaboration across disciplines may be financial as a way to develop relevant technologies. For example, chemical companies were found to want close links to plant breeders who are developing disease resistant varieties to know what products they should be developing to complement these (Case 5).

Commercial pressure on Unilever to both identify long term sustainable sources of products and to demonstrate environmental concerns to shareholders and customers, led to the cross disciplinary Sustainable Agriculture Project:

“We realised that we were heavily reliant on agriculture for so many of our products and if it goes then there is no business for us. For us there was a real wake up call with the fish business when we realised the effect on fish stocks from the way fishing had been carried out before. So there is genuine commitment for sustainable sources in the future although other companies do see it as a marketing ploy” (4.110). The programme is funded from a central source within Unilever and had considerable support from the chairman. It [the company] is also proud of its position as number one in the Dow Jones Sustainability Index”.

Table 1.1 Different disciplines and types of farmer involvement

Project	Description	No. orgs involved	Diversity of disciplines	Types of on farm research
1. Home Farm Organic Study	Impact of organic farming	4	Socio-economists, ornithologists, ecologists	Biodiversity – flora & fauna Nutrient monitoring Farm economics
2. WildCRU on Chichester plain	Restoring water voles & other species	3	Ecologists	Biodiversity monitoring Habitat manipulation
3. Saffie	Agri-environmental measures	10	Ecologists, entomologists, ornithologists, statisticians	Crop & margin management experiments
4. Entry level Scheme	Evaluation of the entry level scheme pilot	8		Pilot ELS Farmer questionnaires Biodiversity surveys
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	1	Plant breeders Management	Product testing (varieties)
6. Orange Blossom Midge	Identifying resistance & developing traps	7	Entomologist, geneticist, plant breeder	Product testing (traps)
7. Unilever	Crop and agri-environmental trials for sustainability	5	Ecologists, agronomists, hydrologists, ornithologists, soil scientists.	Research farm and involvement of Birds Eye pea growers
8. Nitrates	N Management in Organic farming	3	Organic farming, nitrogen, FYM & crop physiology experts	Field & farm data taken from farmers
9. Pig welfare	Developing pig welfare assessment	2	Animal ethologist, vets	Welfare assessments
10. Biosecurity	Constraints & incentives to biosecurity uptake	2	Veterinary epidemiologist, socio-economist	None

When developing the methodology for the projects studied here, researchers had to decide whether experiments would be more suitably conducted at a research station or on a commercial farm. Although some of the projects studied here carried out most of the work at a research station, these projects also all had some element that involved work on-farm. For example the Wheat Blossom Midge project carried out research on station, then provided farmers with pheromone traps and asked them to test them to provide feedback. Projects with a broad focus, such as biodiversity, required an on farm approach in a commercial situation, for example, in the SAFFIE project, the Home Farm Organic Study and the Chichester Plain Sustainable Farming Partnership.

In terms of the methods of data collection, the cases examined here were diverse in their approaches, dictated by the hypotheses being tested. The Home Farm Organic Study aimed to find the ecological and socio-economic differences between organic and conventional farming, so compared fields within these types of farms. This differed from the Unilever Sustainable Farming project, where the treatments were less fixed because they were carried out on a commercial 'research' farm used for demonstrations.

The Unilever project was designed in this way because the researchers felt that their project has a 'horizon scanning function' (2.28) rather than hypothesis testing. The research that Nickerson's carried out was also of a similar 'inductive' nature. The farmers told the plant breeders about their experiences both with particular varieties and growing wheat in general and the breeders use this when selecting new lines and recommending what agronomic inputs should be used for varieties. One of the breeders commented on this.

"I get feedback from it. I get what they like, what they don't like, I get lists of priorities. I get some fairly robust phone calls if our variety's performed badly" (t.1.8).

The agro-ecosystems approach also requires researchers to examine a range of factors that include interactions in the natural environment and social or economic issues. The study on bio-security came to the conclusion that social factors were important in determining the level of mastitis in cows: "I found out mastitis was often linked to other things, like if the herdsman was getting divorced or depressed ... these sort of things showed they were not going to try something new because it needs confidence" (1.18).

1.3 Bringing scientific data from different scales together

Agricultural research is generally conducted as reductionist, factorial experiments at scales that are different to those for which the recommendations are made. For example the early 'no till' technologies worked well with small tractors on trial plots but led to compaction when carried out with large tractors (Suppe, 1987).

Agro-ecosystems research, however, requires the analysis of all interactions in a farming system, which usually entails working at a larger scale, both spatially and temporally (Drinkwater, 2002). More than one scale may also be studied to gain further insight into a particular aspect of an agro-ecosystem by, for example, using subplots within a larger experiment to test a specific hypothesis (Harris *et al.*, 1994).

The scale chosen to work at differed among the projects studied here depending on the data being collected whether this was a transect in the case of the Chichester Coastal Plain Sustainable Farming Partnership, small plots in the case of the Orange Wheat Blossom Midge project or field scale as used by those working on the

Birdseye Unilever Sustainable farming project. In the majority of projects hypotheses were tested at one scale although some did work at different scales and brought results together for interpretation.

Table 1.2 Integrating scales in each case study project

Project	Description	Scales Examined	How scales were integrated
1. Home Farm Organic Study	Impact of organic farming	Margin Field Farm	Biodiversity & nutrient measures incorporated into economic & social impact analysis.
2. WildCRU on Chichester plain	Restoring water voles & other species	Transects (100m to length of farm) Landscape	Integrated when displayed on maps.
3. Saffie	Agri-environmental measures	Margin Field	Initially scales kept separate. The final experiment combined best field and margin treatments.
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Farm	One scale used but extrapolated
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Plot Field Farm (costs)	Scales kept separate. Varieties developed in the breeding programme given to farmers to test, multiply and costings.
6. Orange Blossom Midge	Identifying resistance & developing traps	Lab Plot Field	Scales kept separate. Traps developed & given to farmers to test.
7. Unilever	Crop and agri-environmental trials for sustainability	Split fields Whole farm	Scales kept separate.
8. Nitrates	N Management in Organic farming	Field Farm	Models.
9. Pig welfare	Developing pig welfare assessment	Farm level	n/a
10. Biosecurity	Constraints & incentives to biosecurity uptake	Farm level	n/a

In several of the cases, different project partners did conduct separate experiments looking at different aspects of a problem, possibly at differing scales. One example of this was the Orange Wheat Blossom Midge Project where the researchers from ADAS and the wheat breeders tested varieties for resistance to the midge, scientists from Rothamsted Research developed the pheromone traps and scientists from JIC studied the genetics of resistance. Another example was one aspect of the SAFFIE project where some partners were studying arable field margins whilst others concentrated on the fields.

In two of the cases the results from small-scale experiments were used to decide what should be given to farmers to be used at the field scale. With the Nickersons' Buster Club, conventional plant breeding methods were used at a small scale and then the resulting variety was given to farmers to see how it would perform on a field scale. Another example of this method was the Orange Wheat Blossom Midge project which tested different pheromones in midge traps and then sent the best trap to farmers to test. In the latter case it was considered that the small-scale experiments were sufficient to test the relative performance of product and so no comparisons with other products were made at the field scale.

In the case of the Entry Level Scheme Pilot project, the data was collected on one scale and then extrapolated. The likely environmental impacts of the Entry Level Scheme on a national scale were estimated from results from a sample of farms covering a range of farm types on the basis of the relative proportions of different farm types across the country.

The WildCRU study found that larger scale testing was 'resource hungry' and that 'often people work on a small scale because that is what is manageable' (w.1.263-4). However, after the Chichester coastal plain sustainable farming partnership project ended WildCRU started working on a research project at the landscape scale.

In contrast to how most projects are conducted, the Birdseye Unilever Sustainable Farming Project proposed to start looking at treatments on the field or split field scale and subsequently carry out experiments at a small-plot scale: 'The idea was to go to smaller plots if there was an effect we were interested in and we wanted more information.' (w.57-58). However, it was decided that the resources were not available to do these smaller scale experiments and so the project continued to look at the split (halved or quartered) field scale.

It was notable that projects focusing on biodiversity and measuring species richness did carry out research at different scales. This was partly the case of tailoring methods to species being studied. For example species such as plants and insects can be looked at over a small transect or in a quadrat whereas, for example, birds operate over a large area. In WildCRU's Chichester Coastal Plain Sustainable Farming Partnership, researchers found that:

"You need to look at different species on different scales particularly when you are looking at mammals. For example, shrews may only move a few metres in their whole life, voles may cover 1 kilometre while an otter can cover tens of kilometres" (w.1.249-252).

Another project where this issue had been encountered, although for a different species, was the SAFFIE project.:

"We look at four fields per farm and there are different treatments in each field. We look at the field effect and where birds are foraging and see if they select particular sites Sometimes the scale can be too small for many bird species but it is hard to set up bigger scales" (v.7.145-149).

In the case of the Chichester Coastal Plain Sustainable Farming Partnership, despite assessing different species at different scales the results for a selection of the species were displayed on a map of the area at the same scale. The map showed farm boundaries and waterways and the numbers of the species found either on each farm or along the ditches and canals.

One project that integrated various types of data from different scales into one output was the Home Farm Organic Study. This involved collecting data on biodiversity and nutrient leaching and allocating a cost to the benefit or disbenefit of these things and then combining this with farm financial data. The outcome was an assessment of the economic and environmental impacts of organic and conventional farming methods in terms of pounds per hectare (Cobb *et al.*, 1999).

1.4 Conclusion

This project specifically chose case studies demonstrating a range of the elements for agro-ecological research, with a particular emphasis on involving a range of stakeholders and being interdisciplinary. Our research started by emphasizing the role of farmers, but this study has also demonstrated the important role of other stakeholders such as funders and lobby groups

The scale of the research projects varied, from research at farm level to that at regional or national level (e.g. Pilot ELS). In some cases, detailed research at laboratory or plot level was scaled up to field testing (e.g. testing wheat varieties and pheromone traps). On the other hand, the Unilever project started with its focus at the field level, and expected to scale down to focus in more detail if problems identified at the field level needed further consideration.

Research involving biodiversity necessarily required a wider, landscape scale approach. Several of the projects collected data on the frequency of species within habitats, and then scaled up the measurements depending on the frequency of those habitats in the wider landscape. Within this, some pragmatic choice of scale at which to conduct research was made, based on the size and range of the species being identified.

Explicit consideration of systems was clearly evident in the cases studied, and many of the projects did draw on systems thinking in the design of their work and in terms of how they present their findings for a non-scientific audience. This is particularly important for farmers as they have to operate holistically and require recommendations that take into consideration the multiple objectives they have to meet.

Part 2: Farmer learning and research

2.1 Introduction

The diversity of farming systems in terms of economic activity and different practices is a response to differing ecologies and the ways that farmers learn about their own land and animals. Through learning from others and trying out new activities, they are able to develop farming systems that they perceive to be best suited for their land and the context of their farming enterprise. This section will explore how farmers balance a wide range of factors in their decisions concerning what farming practices to use and what changes to make. The research will also examine the process by which farmers try out new activities. We postulate that farmers adapt technology and processes (rather than adopting them), and there is a need to understand how they try out new things – a process that is a form of research or experimentation.

Much of the existing research has prioritised the roles of scientists and on station trials while users of the research, particularly farmers, are perceived as passive recipients of technology, what Biggs (1990) refers to as the central source model. However, empirical studies show that there are 'multiple sources of innovation' including agri-businesses, universities, farming organisations and farmers themselves. A survey of almost 500 farmers in Kansas US found that 75% were doing some form of research (Norman et al, 1998). A survey of nineteen East Anglian cereal and pig farmers found that all except two were doing some form of experimentation (with 74 cases identified), although many did not classify their research as experimentation but rather part of their ways of learning (Lyon, 1996). A distinction can also be made between radical and incremental innovations. In this study farmers were found to be involved predominantly in incremental changes such as trying new varieties of wheat and comparing to existing varieties elsewhere on the farm, and using different means and timing for hedge cutting. One farmer stated: "I suppose I've always fiddled around with hedges" (u.1.109).

Farmers' own research and learning covers subject areas that are most relevant to a farmers' specific situation (Bentley, 1992; Haverkort, 1991;8; Farrington and Martin, 1988;21). It can therefore cope with (and encourage) diversity such as the differences in soil, climate, historical land use patterns, labour availability and the aspirations and experiences of the farmers (Van der Ploeg and Long, 1994; Van der Ploeg, 1990). However, it is only applicable to the local situation "in the context of a myriad of changing variables, many of which are specific to that one particular farm" and "it is not clear how often these solutions are applicable to a widespread number of situations" (Molnar et al, 1982: 86).

Farmers develop a deep understanding of the farm as a dynamic system, varying over time and between or within fields, while the reductionist methodology of conventional scientific research cannot cater for the contexts of individual agricultural ecosystems (Odum, 1989: 177; Bawden, 1991). Pretty (1995) proposes that an important part of sustainable agriculture is the process of learning and adapting to a particular place and time.

2.2 The epistemology of farmers' research

The process of farmers' experimentation may not appear as the testing of structured hypotheses so a wider definition of experimentation is needed that goes beyond the positivist concepts of experimentation (Scoones and Thompson, 1994). Okali et al (1994) have a definition with the two essential aspects being firstly the creation of

treatments or initial observation of conditions; and secondly observation and monitoring of results or effects (Okali, et al, 1994).

Two methodologies of farmer experimentation can be identified:

1. Hypothesis testing for solving problems, adapting technology or for curiosity. These may be similar to conventional scientific research
2. Experiential research and 'accidental' experiments. Experiments can come about when a farmer is forced to try something new or a chance event such as weather or a mistake allows them to make an observation.

Our findings presented below suggest that farmers manage their farms by adopting complex 'system level' or holistic thinking to link important agronomic, economic and social decisions (yield, labour requirements, input requirements, market opportunities, visual appearance, taste, relationship to other livelihood options and ecological services) (Farrington and Martin, 1988;46; Van Dusseldorp and Box, 1993;23). Similar conclusions have been drawn from studies of systems thinking where individuals have to balance multiple criteria when making decisions (Checkland; 1989). Suppe (1987) shows that farmers have to decide on a configuration that balances different objectives, and that there is rarely a single solution. The case below demonstrates the multiple criteria that farmers have to draw on

"We also do our own trials with different grazing methods, looking at how cows access their grazing in different ways, by moving fences and access points at different angles and using back fences, I might try it one way and find there's not enough space so do it another way and see if they are happier. This is important, very much a welfare issue and I will go out there at half six in the morning and just stand there scratching my head. It's great fun. It's all over the place now. The cows must be getting very confused but it's all about cow behaviour.

What factors are you looking at specifically?

I want the cows to utilise the grazing as much as possible but its difficult because of the weather and ground conditions. ... also you might find cows in a field are happy while those in another field are not. So you just ask why - why ?

So what are you actually looking for? So many things – it 's whether they get muddy, also look at the yield, but its not just which way I move the fence, I need to assess the size of the area for each 12 hour period and I ask what do the cows like ? I failed on one bit because there was not enough grass ... - ... Does it matter why, I ask myself, I'm not sure but I need to know for my own curiosity. I want to move this approach to other field so I need to know. Another factor is whether the cows are lying down or not, it's all about their comfort.

When you make some of these other changes how do you know it's beneficial.

Its natural stockmanship skills, it's how comfortable they are because a comfortable cow is likely to be profitable"

I've made it difficult because I've made so many changes. For the vet it's easier to change one thing at a time and see the impact of that, but here, as well as the new milking parlour, we had new cow housing in November, we changed some of the cubicles from straw to sand.....We are also changing the grazing management" (2.10).

The process of generating information depended on the subject area and the treatment, although in many cases it differed from the 'scientific' approach in that it was informal, without rigorous control and replication. However, in arable systems it is easier for the farmer to leave a part of a field untreated to assess whether there is

any effect. Measuring, observing and evaluating the results may not be done as rigorously as conventional scientific research. Farmers may have a different concept of 'check' to the researchers with validation coming from "inter- instead of [as well as] intra-farm replication" (Farrington and Martin, 1988; 62), comparison to previous years and peer critique (Richards, 1994).

Farmers such as the dairy farmer in the case above were also observed to be using multiple treatments simultaneously as part of their usual working practices. If there are too many variables in the experiment, interpretation of results is very difficult (Reijntjes et al, 1992: 53) especially when there is much interaction of production factors (Stolzenbach, 1992; 9). Variables may also change through the year in response to practical farming concerns. One organic farmer noted: "we are very flexible. It is science but we are not governed by the same things. For example I had not planned to top dress with compost, but the crop looked sad and so I thought we could try that because we were going to trial compost next year".(11.1)

Farmers' own research also has considerable limitations that can lead to unjustified conclusions being drawn. These include the lack of replicability and control, inaccurate measurement and success attributed to the most obvious factors or those that are "directly perceivable to their senses" (Stolzenbach, 1992: 11 and Bentley, 1992: 3). This can lead farmers to develop ideas that are misleading, not sustainable or dangerous (Seppanem and Padel,1999).

Experiments on farms can occur from chance or unintentionally as have been observed in studies in UK and Africa (Richards, 1994; Lyon, 1996: Stolzenbach, 1994:159). Dyke (1974:4) in his text book for scientists on field experimentation refers to "accidental experiments when a field may be given different treatments, such as ploughing on different days due to interruption by bad weather. An interviewee had had accidental mixtures of crops in a field due to a mistake during sowing but the crops had grown very well for silage and he repeated it in future years. An organic arable farmer stated:

"I have tried different drilling times, but often by accident,... just by circumstance. I found that the later sown crops out-yielded others so I am convinced. The temptation is to put it in early, especially when there is a mild autumn. But now I've tried to go later." (11. 2).

As mentioned earlier, innovation may not be seen as research or experimentation but as the way people learn. In this way innovation is part of the informal organisational learning (Porter, 1990; Smallbone et al, 2003), and part of what Bessant et al (1994) refer to as 'continuous improvement'. In the experiential approach to research and learning, farmers evaluate through what Schon (1983) calls "reflection-in-action" either during the action ('thinking on your feet', 'learning by doing' or 'keeping your wits about you') or after (either immediately or over the course of several months). The evaluation is a continuous process through examining the direct impact of the operation throughout the season rather than only evaluating the output.

Farmer research can be done subconsciously and form part of the farmers' tacit knowledge. Tacit knowledge is hard to define as it is based on the premise that "we can know more than we can tell" (Polanyi,1966: 4) and it is difficult to write down or formalise. Ambrosini and Bowman, (2001) refer to it as mental models that individuals can follow in certain situations. Nonaka (1991:98) compares it to the skills referred to as a 'know how', "deeply rooted in an action and in an individual's commitment to a specific context – a craft or a profession, a particular technology or product market, or the activities of a work group or team". Collecting data is

particularly hard but it is observable from pauses in interviewee responses and from the time taken to reflect on questions by the interviewee, as well as some specific responses.

The assessment may not be explicitly acknowledged until asked the question; “*So how will you know that it is working?*”

“That’s very good question... Very subjective analysis I’d imagine. What will I be looking for, [pause] very interesting..... I will compare that with what came from stuff that we grew last year, then I guess it’ll be just a visual monitoring, the important bit will be yield, the important bit will be whether one comes down with a load of disease that the other one didn’t, how does it germinate, all those sort of things. I don’t think I’ll be doing it particularly scientifically necessarily, it’ll just be a overall impression that, that worked or it didn’t work. (11. 4)

The example of the case below shows that farmers may carry out the assessment almost subconsciously:

“we’ve just changed to use a contractor who has two drills and we have one too. We also tried a demonstration drill for about forty hectares. *How do you know which is better?* I guess it’ll be to do with seed placement and coveragenumber of cultivations...germination....; you just sort of log these things away I think as you go around but then it might then prompt you to actually go back and try to be a little bit more scientific. But I guess because it is in the back of your mind it’s just for your own personal use, so you don’t tend to record it all and say “oh right that’s how to justify XYZ”. It’s more of a sort of, I think... its driven by something you notice yourself and then you think ... ah maybe I better try and put a bit more of a handle on it.” 11.4

The actual assessment of crops may not be done formally: One farmer stated “It just doesn’t feel like it is research it’s just,I mean over the years we might see the difference” (11. 9.8). “I’m researching all the time like where to put the electric fence. It’s a kind of research just to watch cow behaviour” (o.2.10). Other interviewees denied doing any experimentation until part way through the interview and they had reflected on why they were carrying out their operations as they were.

Much of the innovations concerning machinery are referred to as ‘tinkering’ and involve applying tacit knowledge held by farm workers or technicians, rather than farm managers: “I just knew about 85%. I know it sounds big headed but I just know” (11.12.3)

Other farmers referred to relying on their feelings:

“I don’t do replications. You can have a strong feeling but you can’t say hand on heart. I try to use the information I have, or part of it”.(11.2).

“I will get a feel of it when I do the crop inspection , and if I don’t like it I won’t grow it again. I will ask , does it impress me? and I know the circumstances.”

2.3 Learning with advisors

Intermediaries and advisors can play a key role in both stimulating farmers’ research through helping them articulate needs, drawing on comparisons with other farms and giving ideas of possible solutions and offering diagnostic and evaluation support (Smallbone et al, 2003; Seaton and Cordey-Hayes, 1993; Oakey and White, 1993; Hassink, 1996). Furthermore, intermediaries and advisors build up their knowledge and expertise through a process of experiential learning, comparisons of their clients business processes and even small research projects (Lyon, 1996).

A survey in East Anglia found that agronomists carry out experiments with farmers on spray dosages (Lyon, 1996). Agronomist consultants and chemical distributor representatives ('the reps') are usually trained in formal trials but their work entails working closely with farmers. They generate much knowledge by learning from action, although they may not think of it as research and can be unwilling to admit that they do it. It is necessary to fit a technology or husbandry approach to a certain field or a part of a field that has a unique set of circumstances, certain soil, a certain weed problem and a history. As one agronomist said; "each farm has different crops, different soil and different land types also different ability to do things.. we have to get rid of this idea of a blue print".

An advisor on environmental stewardship reflected on his use of this 'informal research', drawing on analysis through networking and referring to the importance of this form of learning for building tacit knowledge:

"It is a balancing act of treatments being good for one species rather than another.. it is very difficult.. you have to use your own judgement... [Is this research?] We are not doing research ourselves, just putting it into practice. But then when we look at margins we can see what works and what does not, the same for coppicing and so we can recommend what seems to work . I suppose you could call it very informal research.... We share it informally through chatting and FWAG has a web site knowledge base for sharing . You get lots of stuff from just going around farms and then we can recommend a farmer to go to another farm. A lot of it is in the back of your head.. that is the nature of the job" (2.2.j)

Agronomists play a vital role comparing many farms with the same treatment. Without this replication, they claim that farmers would make horrendous mistakes but some farmers are worried about being used as 'guinea pigs'. A common area for experimentation concerns agro-chemical dosages. The recommended dose is almost always above the necessary dose for the majority of conditions, a factor that chemical companies are beginning to admit: A chemical company itself stated: "Label doses are generally set to give 90% control in 90% of situations. That implies a high level of disease control ... but it can be a belt and braces approach which costs money and is not appropriate in all situations" (BASF, 1994: 14).

Advisors play a particularly interesting role in that they are the main users of the scientific output, which they can combine with a knowledge of the practicalities of farming and a knowledge of the local area. They therefore draw on these different forms of knowledge to make qualitative judgments of possible courses of actions for each business and help the businesses to decide what to do (Suppe, 1987:12). However, it should be noted that there are many business advisors, extensionists and consultants who do not have local knowledge and continue to rely on diffusing scientific information in a crude 'top down' process. This approach is less likely to be acceptable to businesses who are paying for the advice and who are becoming increasingly demanding of solutions tailored to their specific local problem.

2.4 Learning through networking

The sources of ideas comes from observations of farmers, interactions within the business and from sources external to their business. One farmer noted:

" 50 % of my ideas come from coffee room chats, like when we're just having a fag and a coffee and lots of it is about what-ifs, eg do we use Urea or ammonium nitrate" (r.3.100)

Businesses that are well networked are likely to have more ideas. Rothwell (1991) describes innovation as a process of 'know-how' accumulation and that "successfully innovative firms generally are well plugged into the market place and to external sources of technical advice and expertise". However, the propensity to engage in networks differs between businesses and the types/scale of networks used depends on the extent to which specialist knowledge is used (Smallbone et al, 2003). In this study, informal networks of farmers and farm walks were found to be important sources of comparisons of crops with different treatments:

"I might be thinking about doing something that can be completely off the wall and I can say 'look I've been thinking about doing this, do you know anybody who might be doing this, or do you think this is completely daft?' Its quite interesting to hear that you're not the only one doing it or that somebody else is trying to resolve it another way. With the new things we are doing, we've talked 'bout it and that perhaps we ought to be trying to quantify it more than we have been because we've probably been down the subjective route so far and perhaps we'd like to try to be a bit more objective about it."

Benchmarking and discussion groups were also reported to be important where "we bare our souls to themIn the discussion group meeting, when someone has done something which worked we want to find out why and that is research and technology transfer all at one time. Sometimes you might have a scientist or a facilitator with you or a specialist like a vet, other times you won't. " (o.2.7). In these circumstances trust is important so that participants can talk freely and feel that they will be loose face or loose commercial advantages.

Farming businesses are more likely to be interacting with those firms that share a similar knowledge base and are considered as peers. Indeed, research on small businesses in general has shown that business partners and customers are the leading stimulants for change and innovation (Rothwell, 1991; Dankbarr, 1994). However, these relationships can be limited in scale and result in businesses being 'locked-in' to particular ways of doing things (Grabher, 1992; Smallbone et al, 2003)

2.5 Types of farmers and motivations

Factors that influence the extent of innovation in a business include the personal characteristic of the owners (including education and experience), combined with resource availability and organisational issues (Smallbone et al, 2003). Cohen and Levinthal (1990) use the term 'absorptive capacity' to refer to a business's ability to assimilate and value new knowledge. The extent of absorptive capacity is dependent on prior knowledge, on-going research and diversity of expertise allowing individuals to make novel linkages and associations. Studies of farmers distinguish a category of 'research minded farmers'. The extent to which this is a useful category will be explored in the survey. There are a range of classifications that attempt to identify types of businesses and their owners (such as farmers) depending on the extent of their innovation (Rogers, 1983). However, these crude classifications fail to recognise that firms change over time and go through periods of more and less intensive innovation, and that much innovation may not take place explicitly within a formalised research and development programme.

The study found that there are some farmers who relish the idea of trying new things: "If there's anything possible to change we're always trying. I'm not interested in what the neighbours are doing – like if they're spraying one day I don't care I always look what's best here but I do want to see what other farmers are doing because if its successful, then ok....." (o.2).

“Well, I always make a big mistake every year! (laughs) I did try growing beans and lupins together. You know, things you try once and don't do again. But life's boring without trying new things” (q.5.2). It is this inquisitiveness that makes them more likely to participate in research projects with farmers (as discussed in part 4 of this report). A personal interest in research through work or education was also found in three of the farmers working on research projects with farmers. Farmers may also be attracted by potential media interest in their farm, by the ability to network with researchers or DEFRA officials and by the possibility of having new developments before other farmers. However, this can result in these research projects working with an unrepresentative group of farmers

2.6 Conclusions

Farmer learning was found to be carried out through reflection, networking and with advisors. Farmers were found to be involved predominantly in incremental changes such as trying new varieties or equipment and often experiments occurred from chance or unintentionally.

Our findings suggest that farmers manage their farms by adopting complex 'system level' or holistic thinking to link important multiple agronomic, economic and social criteria. Farmers may have a different concept of 'check' to the researchers with validation coming from inter as well as intra-farm replication. In this farmer networking is an important part of their learning processes, as are the roles of advisors who can compare treatments on different farms. Farmer research was also found to be carried out subconsciously and form part of the farmers' tacit knowledge. The challenge for scientific research is to find ways of integrating this learning and knowledge production into conventional scientific approaches, and to recognize that farmers play a key role in adapting recommendations from scientific research to their own locality.

Part 3: Collaboration and interdisciplinary scientific teams

3.1 Introduction

As mentioned in the introduction, research on agro-ecosystems is both interdisciplinary as well as being transdisciplinary or ignoring the artificial disciplinary boundaries and territories established by academics. From the farmers' point of view, disciplines are irrelevant, as he or she juggles the different knowledges and skills required to farm successfully. In this way farmers can be considered as systems thinkers linking disciplines. Interdisciplinary research has been defined as an integration of ideas from different disciplines, drawing on each others' theories, research methods, and ways of viewing world (Sillitoe, 2004). In this section, we examine the extent to which the selected case studies have developed interdisciplinary approaches and the challenges different types of researchers face. How these types of researchers can engage in 'transdisciplinary' research involving farmers will be explored in part 4.

While multi-disciplinary research can involve different disciplines carrying out their own research on a common topic, inter and trans-disciplinary research involves different disciplines being involved in setting the research questions, establishing the research design and analysis and drawing conclusions. Each of these stages present specific challenges in the case study projects. A criticism leveled at some past experiences of research across disciplines has been the lack of engagement between people of different disciplines with each person following different perspectives and priorities. Crow (in Sillitoe, 2004) states that the three key factors in establishing an interdisciplinary research team are parity, reciprocity, and a common language. Focusing on an issue-based rather than discipline based approach to research makes it easier to bring together an interdisciplinary research team.

The agreement on the overall aim of the research project, and then on how to take this desire for joint research forwards requires negotiation and agreement on research priorities and goals (Flora, 1992). However, the underlying premises each discipline brings to research are different, and there can be conflict at this early stage in research. Differences in the way disciplines frame the objects of their study (ontological heritage) can jeopardise cooperation (Brewer, 1999a), and yet problem definition is the key to developing a common vision of the project (Brewer, 1999a). Whatmore (2005) suggests that interdisciplinary research involves taking risks with the intellectual agenda to develop new techniques and communities of research practice.

Moreover, the language used informs researchers' views of the world, and understanding of research problems (Sillitoe, 2002). Ideally, members of the team should be comfortable talking about research with colleagues from the team. Indeed, Sillitoe (2002) points out the merits of being able to argue one's academic case comfortably with those of other disciplines, being familiar with their terminology and vocabulary. Interdisciplinary work has been considered analogous to cultural journeys, with the need to consider oneself as a "visitor to other disciplines" (Galmiche-Tejeda, 2002), "landing on alien shores, you must begin to acquire the local culture, not with the aim of denying your origins, but so that you can gain the full respect of the natives" (Herbert Simon, as quoted (47) in Sillitoe, 2002). In practice, researchers are usually happy venturing into overlapping areas in neighbouring disciplines, but get less and less comfortable as the gap between disciplines becomes larger. This is even more true when researchers are asked to bridge the divide between natural and social sciences, where key phrases, research

approaches, methodologies, are all different, as is reflected in the language used in discussions.

The combination of language, culture and research methods define individuals as being from one discipline or another. In the natural sciences where there is increasing specialisation and fragmentation within disciplines (e.g. agricultural science producing plant pathology, weed science, agronomy, soil science, molecular biologists etc), scientists are trained in narrower and narrower disciplines, which makes it even harder for them to consider research issues from a more holistic perspective (Gibbon, 2002).

An important aspect of interdisciplinary agro-ecosystems research is that the farmer should be included in this process (Flora, 1992, Gibbon and Jiggins, (2000). Whereas scientists can have difficulty engaging with the concept of interdisciplinary research, farmers have no problem with this (Gibbon, 2000). Therefore farmers can make valuable members of interdisciplinary research teams, grounding the contributions of separate disciplines in the reality of the interdisciplinary nature of farming.

3.2 Motivations to be interdisciplinary

Many researchers have noted the need for interdisciplinary and transdisciplinary research, particularly in the environmental arena. "Environmental research has unique characteristics because it encompasses both social and ecological dimensions" (Scott et al, 1999, pg 4). Problems such as sustainability, people-environment relations, technology innovation and risk assessment are problems that require interdisciplinary approaches (Thompson-Klein, 2004). Brewer (1999) notes that solutions to scientific problems may be impossible to accept by the decision maker, and hence a more integrated approach may be required to provide solutions acceptable to all. Such an integrated approach may require crossing the boundaries between different knowledges (disciplines) and between scientific knowledge and tacit knowledge (Lawrence and Depres, 2004).

The nature of the research questions in each of the projects selected as case studies requires an element of integrating the various research approaches. For example the interest in involving farmers in the research necessitates a transdisciplinary and interdisciplinary research approach that can examine the commercial (economic and social) aspects as well as production.

However, the most common motivation for carrying out research across disciplines and with farmers, is the pressure from public sector funding. This is observed in six of the ten case study projects. It is also interesting to note that in four of these cases, interviewees stated that they felt that the project was considered very different, or 'odd' compared to other more traditional mono-disciplinary research.

There is a common perception that funding for interdisciplinary research is not forthcoming, (and this project had to search for examples to use as case studies). Much funding for research, including agricultural research, comes from institutions or bodies which are clearly either of a science or social science background. Although there is an increasing interest in interdisciplinary research, this is not reflected in the value of research funding earmarked for this.

Table 3.1 Motivations of researchers to work across disciplines in each of the case studies

Project	Description	Motivation to work across disciplines
1. Home Farm Organic Study	Impact of organic farming	To examine the research question and the requirement of research councils
2. WildCRU on Chichester plain	Restoring water voles & other species	To meet the needs of organisations involved in the partnership
3. Saffie	Agri-environmental measures	Requirement of the LINK programme officers in DEFRA
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Specific requirements stated in the invitation to tender documents from DEFRA
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	To develop new varieties that will be popular with farmers and profitable
6. Orange Blossom Midge	Identifying resistance & developing traps	To examine the research issue and with the support of DEFRA's LINK programme
7. Unilever	Crop and agri-environmental trials for sustainability	To meet Unilever's demands for understanding sustainability in agriculture
8. Nitrates	N Management in Organic farming	Responding to a call by DEFRA but research team identified the need for an inter-disciplinary approach
9. Pig welfare	Developing pig welfare assessment	Desire of the researcher to understand farmers' views and develop tools for farmers and vets
10. Biosecurity	Constraints & incentives to biosecurity uptake	Responding to a specific call from DEFRA for research

It is widely believed that applications for interdisciplinary research are often rejected because they do not meet the criteria for funding of either science or social science funding bodies, in spite of being attempts to address important research questions. Quite simply, they fall between the two, being rejected by natural science funding bodies for being to "soft science", and by social science bodies for being too scientific. Some academics claim that research councils see interdisciplinary research as "wishy-washy" (Lau and Pasquini, 2004). Similarly, applications for applied, on-farm research often fall between the criteria for pure research funding, or extension work. Scott et al (1999) argue that "interactive research" is not seen as the norm, and funding systems and institutions are not set up for it. They suggest that funding agencies should adopt evaluation criteria which recognise the benefits which interactive research can bring. This will require a cadre of more understanding reviewers and evaluators, and perhaps the inclusion of utility as a funding criterion. Furthermore, they claim that when budgets or priorities change, interactive research can be the first victim.

There are research programmes which seek to promote and ensure interdisciplinary and transdisciplinary research. The ESRC RELU programme, joint NERC-ESRC scholarships for postgraduate research and DEFRA's LINK programmes are all examples.

The role of funders in encouraging the integration of disciplines is particularly interesting in the SAFFIE project as it evolved out of three separate interdisciplinary proposals:

"There were three consortiums to put in three projects and the man in charge of link at the time wanted us all to work together. He liked to have big projects rather than several small ones. There was some resistance because each of the consortia and the people in it had their own agenda. He [the DEFRA officer] picked the best bits. This was very cumbersome because there was overlapping skills and had taken time to get people together." (v.2.5)

Similarly, the joint research council project on the comprehensive account over the merits of organic and non organic agriculture came about due to "movement in high places" and "high level encouragement" for research council chief executives: "The project is historically interesting, since it represented the first attempt to get three research councils together to jointly fund an interdisciplinary research project. Thinking about interdisciplinarity was new in 1993, and there was no track record to fall back on" (x.2.10). The research councils were keen to experiment in interdisciplinary research, with the effects of the research process shaping future programmes.

Two of the case study projects arose out a specific calls for research from DEFRA, with details provided of preferred research objectives and methods (Entry Level Scheme Pilot and Bio-security). In contrast the others were a response to more open call for grants. In the two cases of contract research, funders appeared to be more hands on. The Evaluation of the Pilot Entry Level Scheme had questionnaires prepared by DEFRA and had to assess the pilot against prescribed EU success criteria.

While funders were identified as driving forces behind cross disciplinary research, they were also criticised as only having one-off programmes and short term projects that did not allow researchers to continue their interdisciplinary research. Where funding sources relied on using established academics to assess proposals, interdisciplinary proposals were penalised as they did not live up to the expectations of all reviewers coming from very different traditions.

Exceptions to this is where those applying for funding are entrepreneurial in seeking out different sources and adjusting their proposal based on specific knowledge of the review process:

"When proposals are considered there is some sort of meeting where you defend your proposal, xxx seemed to be very savvy about the way these processes work that you have a panel of people there and he said of course some of the people on the panel will not be keen on the project because "it cuts across what he does" or someone on the panel will have a vested interest and therefore, it is very important to know the agenda of the individual on the committee, and know that they may have their own agendas which is not necessarily the same as the funding panel as a whole" (s.2.103). This demonstrates the importance of having information and the power that this provides to the holder.

3.3 Types of scientists in case study projects

The analysis of the case study material shows that a number of different types of scientists can be identified with different objectives, behaviour and aspirations.

Table 3.2 Types of scientists involved in the case studies

Project	Description	Types of scientists involved
1. Home Farm Organic Study	Impact of organic farming	All academic university based
2. WildCRU on Chichester plain	Restoring water voles & other species	Academics and Farming and Wildlife Advisory Group (advisory and pressure group)
3. Saffie	Agri-environmental measures	Contract researchers, Pressure/membership groups, private technology development company scientist and university academics
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Contract research scientists responding to detail specification from DEFRA with membership organizations carrying out studies of specific topics
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Commercial plant breeders
6. Orange Blossom Midge	Identifying resistance & developing traps	Contract researchers lead the project with involvement of technology companies
7. Unilever	Crop and agri-environmental trials	Membership/pressure group and contract researchers commissioned to do studies, co-ordinated by an employee of Unilever
8. Nitrates	N Management in Organic farming	Researchers from ADAS and University of Nottingham and Elm Farm Research Centre
9. Pig welfare	Developing pig welfare assessment	Researcher from Scottish Agricultural College
10. Biosecurity	Constraints & incentives to biosecurity uptake	Researchers (veterinary and social science) from Reading University and from Scottish Agricultural College

3.3.1 Technology company scientists.

Examples of these in the case studies include Nickerson plant breeders (involved in cases 5 and 6), and agro-chemical companies involved in two cases (Case 3 and 5). To some degree this involvement has an element public relations benefit, to demonstrate responsible use of agrochemicals. One researcher commenting on their collaborators stated: "The plant breeders have enjoyed being involved in it, partly because they can then show that they are interested in the greater good and not just a cynical commercial interest" (s.4.158), and involvement with these activities helps build their 'credibility with farmers' if they can be knowledgeable about a problem being faced by farmers. Finally, involvement in these activities is seen as a perk for employees of large companies so they can 'get out of the office'. Bill Angus of Nickersons, notes that he is allowed an element of freedom to be involved in research such as LINK projects where DEFRA part fund activities involving researchers from businesses and other research organisations.

Table 3.3 A typology of researchers involved in the case studies

<i>Technology company scientists.</i>	Examples of these in the case studies include Nickerson plant breeders (involved in cases 5 and 6), and chemical agro-chemical companies involved in two cases (Case 3 and 5).
<i>Contract research scientists</i>	Scientists working for companies specialising in research and extension to farmers, such as ADAS and The Arable Group (TAG) (case 6).
<i>Pressure groups scientists</i>	Scientists employed by membership organisations as active researchers. These include the Game Conservancy Trust, Royal Society for the Protection of Birds, and the Farming and Wildlife Advisory Group, who may use their own resources from membership fees as well as having other contracts to be involved in research.
<i>University academics</i>	Permanent members of academic departments or research units, or those on short-term research contracts. In one case, there was an applied research centre within a university operating as a contract research organizations.

Nickersons' involvement in LINK projects

The Link projects are not things which actually require the company to invest money in terms of giving money away; it is much more about support in kind, providing staff time, providing resources and therefore it is quite easy to convince senior managers that it is worthwhile investing staff time in collaborations. As long as the unit is making money senior managers give staff freedom in how they allocate their time., However, the challenge for those in the private sector is identifying those projects that would be good for business. They also benefit as they are able to be involved in research without employing a large number of researchers: "We're not rich enough to have lots of researcher workers in white coats, reinventing everything, so what we do is we come to agreement through things like LINK projects to work on specific projects in a collaborative way... And we will do it with other plant breeders...there are some who are very good to work with, some others want to reinvent everything and aren't prepared to collaborate" (1.7a).

Involvement can also help build networks that can be drawn on serendipitously in the future: "Why does the company do it? Partly for the results, partly for the networking - in doing the research no matter what the results you get you do get to know other people ... there is a spider's web of connections with other workers that has developed over the years. That means that you know people so that when you have other queries or you need other information, you know who to contact and if you already know them you can just ring them up and say 'look I have got a little question for you, or can you point me in the right direction for this'.... you do not need to be an expert but you need to know someone who is and that that networking provides him with the knowledge of those people who are. " (1.45)

However, there is a perception amongst farmers and advisors wanting to liaise with plant breeders that many other plant breeders are less willing to work with farmers directly: "The boffins do not understand the farmers.... I've realised that the people in the plant breeders and scientists are far removed from what farmers are doing. Scientists are in their cocoon and not talking to farmers but xxx can ring farmers up directly" (t.2.119).

The lack of involvement of other plant breeders in collaborative projects can be attributed to elements of competition with similar companies and to fears that the

results will be negative about their products. This is discussed in the later section on challenges of bringing different disciplines together.

3.3.2 Contract research scientists

Much research with farmers is carried out in companies specialising in research and extension to farmers. ADAS is the largest company carrying out this sort of research and due to its history (as previously part of the Ministry of Agriculture, Food and Fisheries) it is able to build on its experience of working with the public sector. Other examples include The Arable Group (TAG) (case 6), the result of a recent merger of a range of private and farmer owned research centres across the UK. These organisations have a reputation of successfully managing research for the public sector. They use the language of the private sector when referring to work with the public sector (“we get on with what the customer wants” and “we manage the interaction and make sure milestones are met”). Central Science Laboratories (Case 4) are similar although they are still an agency of the public sector. The links to extension are also used in their research as a way of recruiting farmers and demonstrating their applied nature. One contract researcher was described by a collaborator as “not a desperately academic academic....he feels privileged to be an ambassador to deliver information to farmers” (s.2.173)

They are perceived by other researchers as being of high quality but with less of the personal commitment of other researchers: “they are more like civil service types”. Contract researchers interviewed reported that they are under considerable pressure to bring in funding:

“we are a bit like a hamster in a wheel, we have one project after another, so publishing would be nice, but the chance to do this is few and far between” (u.2.193). There is some pressure to publish in peer reviewed journals as this can show that they are credible researchers and improve the CVs of those applying for new projects. “It’s like a calling card and it may help get other grants and get you known” (q.3.7). It can also be linked to promotions of individual staff:

“It can relate to promotion and it is important to CSL to have published papers, so that it can show it’s standing within the scientific community.... We very rarely get money to write papers so we do not have the time when we can do it. We are in a catch 22 because if you have the money then you have very tight deadlines and so no time to do the research and then if you have no funding then you are criticised for that but then you can publish papers..” u.2.203

There are contract research centres that also have some core funding from research councils, such as the John Innes Centre and Rothamstead Research. They are under pressure to bring in funding but have more of a tradition of doing more basic/fundamental research and producing academic publications.

3.3.3 Pressure groups scientists

In four of the case study projects, there was involvement of membership organisations as active researchers. These include the Game Conservancy Trust, Royal Society for the Protection of Birds, and Farming and Wildlife Advisory Group. They may use their own resources from membership fees as well as having other contracts to be involved in research. Organisations in this category are all not for profit organisations registered as charities or as Companies Limited by Guarantee. A core objective of these organisations is to push the interests of their members, get information out to farmers quickly and play a role in shaping public policy. In the SAFFIE case project, the project manager made a distinction between the RSPB researchers and ‘scientists: “People have different ways to communicate. For example RSPB want to get the information on skylarks out very soon but then scientists want data out in journals.” (v.1.93).

Those involved in research with these organisations noted that there are times when there is competition between these organisations to influence policy both in terms of trying to influence the public sector to put their limited funds into their specific area of interest, and in terms of ensuring that measures being promoted by one organisation are not antithetical to the objectives of another. A distinction was also made between organisations that started out as advisory organisations and moved into research compared to organisations that started as lobbying groups and moved into research to support this work.

There is little emphasis amongst these organisations for peer reviewed scientific publications unless they can be justified as way of making lobbying more influential: “We want to have publications with scientific credibility for lobbying; if you’ve got a refereed paper then you have a stronger case”. There are criticisms from other types of organisations concerning the speed at which they release results and the extent of scientific rigor:

“Qu. *Is there a difference in scientific rigour?* ... (laughs) ... That’s a very difficult question, I’m not sure I could really answer that one But some will come from the point of view of good science while others are more for a particular result. Perhaps they don’t think so much about the statistical validity. It depends on the type of organisation they are and their cultures and their pressures. for those in the commercial sector, it might be more managerial pressures while those in academic institutions might be more driven by high quality science. But I must say through all these projects, none of the science is bad science.” (v.7.236)

3.3.4 University academics

Five of the cases examined included some representatives of universities although in all but one of these cases, these individuals were working in applied research centres operating as contract research organisations. For example, the Wildlife Conservation Research Unit at Oxford University has a long history of marrying the academic and practical objectives in its mission:

“In WildCRU in our mission statement it says that we do both the academic and more practical work. For this project we did sheets for farmers soon after the project which for the RAE is valueless but we want to do good for our own objectives. We have to serve too many masters and people have to work harder to make it work on all fronts. We try to be brave – maybe we are foolhardy or just lucky and just shrug our shoulders. We are under perpetual pressure to perform and it can be a biting pressure” (2.3.69). They also carry out similar work to NGOs and attempt to raise money through donations from the public, although they differentiate themselves from NGOs, claiming they have ‘more bite’.

The lack of attention to dissemination to farmers amongst university researchers was observed by many people collaborating with university researchers. One farmer noted: “The key thing is communication. The whole business of very high academic work – the people are extremely motivated academically and its very high quality but they can’t deliver information to farmers so quite often if they can’t do it someone else has to convert it. Some researchers can pick out the highlights and make sure the message is delivered but others can’t. British agriculture has a poor record on this area” (o.2.9).

One farmer reflected on the passion of some university researchers for their subject: “Many of them are so excited about what they have in their trial, like the person doing work on xxxxxxxx has been pushing this idea for 20 years and finally has someone willing to try it. He is so excited about it and his enthusiasm carries it along and he keeps saying it is so easy to do it, just give it a go “ (r.3.147).

There is a common perception, held by many stakeholders involved in applied research (researchers, farmers and advisers), that objectives of academic research are directed at what is publishable in mono-disciplinary journals, rather than being directly relevant to farmers. Attempts at interdisciplinary work are not rewarded in career structures. A former head of a University department stated:

"Middle managers (like Deans) are driven by performance yardsticks, and so instruct their 30-40 year old staff members to aim for a 4* academic profile, defined by publications, grants, and workshops / events to increase their profile. Interdisciplinarity does not score... " (x.2.71). Two interviewees in universities reported that applied researchers had been threatened that they will lose their job if they do not have a good publication record in time for the next RAE.

A business involved in collaborative research found that some academics were harder to work with: "Sometimes academics are so remote from the commercial world that they don't really understand what is realistic, the research that they do is not necessarily relevant to farmers. I recognise that most academics are promoted by the number of papers that they have got and therefore sometimes on projects they veer off towards the attractions of things that will develop papers and not necessarily towards the commercial benefits, the wider applicability, the more applied stuff." (s.2.165)

3.4 The challenge of bringing different disciplinary contributions together

3.4.1 *Setting the research agenda and methodology*

Different disciplines have different ways of considering a research problem and different approaches to measuring. Therefore there can be a wide range of potential research questions with more powerful groups having more influence. In cases 4 and 10, the public sector funders decided on the research questions while in cases 5 and 7, the private company funding the research set the questions themselves. In the other cases, there was an element of negotiation in how questions were established. The WildCRU project in the Chichester plains faced particular challenges as the project was funded from a wider range of sources and involved university researchers, Farming and Wildlife Advisory Group (FWAG), nature reserve managers, and the Environment Agency.

An interviewee from another project noted: "I think the expression of design by committee applied to some extent here. Different people had different ideas so there was an element of negotiation of what was in there, so compromises had to be made. I think any imperfections in the project might be there because of this". (v.7.113).

An interview from a private sector collaborator in Link projects reported past experiences:

"Projects have been hijacked for academic purposes and they are not very practical... from the point of view of what academics want out of a project, they want papers, they want to build empires, they want post-docs and therefore if a project does go down an academic route the problem is that it can lead to disenfranchisement of the commercial partners, they become less interested and they put less in. I won't join quasi-academic Link projects with little or no commercial work. You have to work with people that you know will deliver and that is the theme that came up at the beginning." (s.2.181).

The allocation of resources was brought up in one case study as a reason making interdisciplinarity harder:

“This project on xxxxxx was difficult because of the difference in perspectives. There were attempts to push them together but it was difficult at times as some of the senior people had different priorities and it was difficult in the steering group because they couldn’t, how can I say, there was not too much flexibility, it was very much towards what they needed to do to justify where the money ... came from. The more multi- or inter-disciplinary they saw, the less scientific robustness they felt it was. They usually work to very strict protocols so it’s difficult to be flexible.” (x.1.132).

Particular challenges are faced in joining natural and social science. Five of the projects were involved in collecting quantitative social and economic data through questionnaires (Table 3.4). The collection of qualitative data was predominantly carried out informally as a way of listening to farmers perceptions

Table 3.4 The use of natural and social science in the case studies

Project	Description	Use of natural science	Use of social science
1. Home Farm Organic Study	Impact of organic farming	Biodiversity surveys	Economic analysis of organic agriculture
2. WildCRU on Chichester plain	Restoring water voles & other species	Biodiversity surveys	Collect qualitative information on farmers' opinions
3. Saffie	Agri-environmental measures	Biodiversity surveys	Economic assessments by ADAS farm advisors
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Environmental indicators	Questionnaire on farmer perceptions with some 'open questions'
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Agronomic data	Formal and informal collection of qualitative data on what farmers want from varieties through talking to farmers
6. Orange Blossom Midge	Identifying resistance & developing traps	Agronom data Pheramone performance Genetic data	Information on the perceptions of farmers collected through a questionnaire sent with traps and informally
7. Unilever	Crop and agri-environmental trials for sustainability	Biodiversity surveys Agronomic data	Limited information on the perceptions of farmers collected informally and through farmer forum groups
8. Nitrates	N Management in Organic farming	Nutrition status of farms	Perceptions of farmers on their farming systems collected through questionnaires and open group discussions
9. Pig welfare	Developing pig welfare assessment	Descriptors of pig welfare	Questionnaires and less formal consultation with farmers
10. Biosecurity	Constraints & incentives to biosecurity uptake	Research questions shaped by epidemiology	Predominantly focus groups, structured and analysed using qualitative data software by a veterinary science and anthropologist together. Questionnaire survey as well.

In two projects there was an element of rigorous qualitative data collection and analysis. This was in the form of open ended questions in questionnaires or interviews as with the Entry Level Scheme pilot evaluation or focus groups in the VEERU biosecurity project. The use of qualitative data was felt to be more of a concern by natural scientists than the use of quantitative social data.

The Entry Level Scheme Pilot project used the qualitative data in conjunction with other quantitative data. They found the qualitative data useful, but carrying out structured interviews by different people did lead to some problems. When asked how a project developed their methodology, the interviewee stated:

"We used a questionnaire because I historically had worked with this sort of thing and so I knew it was analysable. But we had nightmares of white boxes as you can see but I feel its much better to have these ticked boxes and places where people can score their answer...

How did you learn about doing questionnaires?

Just by going my job. When I first started we used hand drawn forms and very specific questions but now I've had experience of questionnaires and lots of projects. You can ask lots of white box questions but then you get these massive reports because you have loads of free text boxes. Its ages to analyse and if there is nothing to force the interviewer to ask the questions and things have been missed out you don't know if it was because the question was not asked or if the farmer was not doing those sort of options anyway. I also realise you can lead farmers with leading questions.

Do you see yourself as a Social Scientist then?

(Laughter) Or a social worker. I spend my time listening to peoples problems on a daily basis. I'm a sounding board and I suppose a target for everything government and DEFRA related. " (u.2.86).

The study of bio-security used focus groups to collect qualitative data:

"I think that the farmers also like the focus groups more than other more haphazard approaches because in the feedback farmers said they enjoyed it because it forced them to think.....For us it took time to get our heads round doing the qualitative data of the focus groups because we just love to quantify things and when they showed us the software I thought this was great that we could quantify things. So it does encourage the counting of things but xxxx the social scientist said: 'no you just can't do that'. But now I'm very impressed by seeing what you can point out from socio-economic research and to tease out the causes. It has been a learning and development process for me— for the socio-economists and anthropologists it must have been exasperating!" (1.4).

Amongst policy makers there is also growing interest in social science, with DEFRA involving more sociologists in their policy work and research activities. One interviewee contrasted this growing interest with agriculture and environmental research in Department for International Development, where there has been a longer tradition of using social scientists The increase in social scientists is partly driven by the need to understand how people's perceptions are shaped by the media and also to understand why farmers and other businesses behave in particular ways. There is some concern amongst policy makers from other disciplines that social scientists may concentrate on stating what cannot be done and why farmers do not take up particular measures rather than 'having something positive at the end'.

Other qualitative information was often collected, although this was not necessarily considered as data. For example, with Nickersons' Buster Club, farmers were telling the breeders what they thought of the performance of various varieties and then the breeders were taking this into account when developing new lines. Also, in the Orange Wheat Blossom Midge project, farmers were giving feedback about new pheromone traps which the researchers were using to improve them:

3.4.2 Drawing conclusions

Interdisciplinary research also faces problems in the interpretation of data and the drawing of conclusions. When researchers have done independent studies (in a multi- rather than inter-disciplinary approach), someone has to bring the work together to interpret the studies as a whole. One of the Link funded project participants stated:

"It is always a compromise in terms of value for money in scientific terms. And some of these projects is science by consensus. The LINK programme has multiple funding and so therefore has multiple objectives". (v.3.247).

The Unilever Sustainable Agriculture Project has tried to encourage their researchers to come to together:

"They are paid by us for these bits of work and we brought them in as individuals and we say what we want to do and ask them what sort of measure they could do. Jos is responsible for this, he has to get them to work together and sits down with all the partners, we find that one organisation does not tend to think about the others, but we are making them produce joint reports, so it is quite a facilitation exercise, it is not the way they are used to working.

What sort of issues and conflicts can arise?

I suppose the only conflict is making people think outside their own box" (1.51)

"The biggest challenge is to have a true partnership and trying to get things intertwined rather than having separate bits. I am trying to get people to write together at the moment for this report. I usually get lots of individual reports from the different organisations but the reader has to make the connections. I don't think we're getting the most out of the information.

I am trying to get everyone together. Get them to edit it, not me to interpret their work. I get stacks of individual reports and I don't think we capture everything in there. It takes longer, editorial meetings, making decisions together, listening to each other's work." 2.d

Researchers coming from different perspectives and concentrating on different factors can have very different interpretations of similar aspects. In two cases the interpretation of the data about the impact of a particular measure was found to differ with one partner organisation stating it was good for the environment and another stating it was bad. This is partly due to the emphasis on different interpretations of the environment and the preoccupation with specific aspects of the environment by some researchers. Finally the findings of the research can also be negative for the commercial or political objectives of one partner with results withheld to avoid conflict.

"xxxxx did restrict project results because it made them look bad in the first year but they allowed them to become available in the third year when subsequent results showed it wasn't that bad" (s.3.127)

3.5 Inter-organisational interdisciplinary relationships

3.5.1 The concept of trust

A challenge of interdisciplinary teams, especially those that include people from different organizations, was found to be the maintenance of good relationships and trust. For collaboration to be successful there is a need for incentives for both farmers and researchers, combined with trust based relationships. These relationships are needed both between farmers and scientists and amongst researchers in teams and amongst farmers in groups.

The concept of trust has been studied in several of the social sciences in differing contexts leading to a mixture of approaches and perspectives (Misztal, 1996: 13). We define trust here as the expectation that people will act as expected and people will make themselves vulnerable to opportunism from others. A dictionary definition of trust is “a firm belief in the reliability, truth or strength of a person; a confident expectation; and a reliance on the truth of a statement without examination” (Oxford English Dictionary, 1995). Trust is based on a perception of the probability that other agents will behave in a way that is expected (Gambetta, 1988). Trust operates when there is confidence in other agents, despite uncertainty, risk and the possibility for them to act opportunistically (Misztal, 1996: 18; Gambetta, 1988:218).

The process of building trust has received relatively little attention in the academic literature with only the work of Newell and Swan (2000) examining trust in university research networks. Zucker (1986: 60-65) has set out three “central modes of trust production”. In addition to institutionally based trust she also refers to ‘*Process-based*’, where trust is tied to past or expected exchange such as in reputation and gift exchange; and *Characteristic-based*, where trust is tied to a person, depending on characteristics such as family background or ethnicity.

Business relationships can also be shaped by trust in a third party or intermediary, and trust shaped on shared norms and business conventions (Lyon, 2000). The building of interpersonal trust involves both calculation and actions shaped by routines and cultural norms. Research on the nature and formation of norms of generalised morality are restricted as they are intangible and difficult to observe. Furthermore studies on the concept of trust and ‘social capital’ by Putnam (1993) and others fail to make a distinction between trust as expectations and general morality in the community itself (Levi, 1996: 46-7). Norms define what actions are deemed to be right or wrong, and include customs of cooperation, reciprocity and interaction with strangers. Norms cannot be produced at will and their creation or shaping depends on the cultural background to the relationship, including market exchange contexts (Platteau, 1994).

There can be norms which restrict the ability to enforce sanctions against others; these are often based on loyalty to people in the same network. Norms can also be applied more consciously and rely on social consensus to enforce sanctions. These sanctions or motivations come in the form of shame and obligations (Scott, 1976). Individuals are pressured into keeping to norms by those around them. This can be done by withdrawal of co-operation, disapproval and attaching social stigma to norm breakers, although this is limited to cases where those involved live in proximity or work closely together. Platteau (1994:765-6) also mentions that norms can be enforced through a self-policing mechanism whereby agents take moral norms and internalise them, behaving morally because of guilt and shame.

3.5.2 Incentives to cooperate

Key issues of trust evident from the analysis of the case studies is, firstly, the reliance on others to carry out the research and secondly the use of the results (in press releases, publications or using Intellectual Property in future commercial activities) or simply “hog the limelight”.

“I don’t believe you get anywhere working in isolation or a vacuum and that openness is much more successful than having secretive research, so that it is important to be talking to people, sharing ideas, potentially they nick a few ideas but on the other hand you also build up good relationships and you find out things from them as well.” (s.2.7)

Trust is particularly important when working in less well known areas and crossing disciplines where research partners may be less comfortable and feel more at risk of external criticism. Who to include in publications and the order of names on a publication are frequent arenas of conflict in academic research and were noted in two of the case studies. In interdisciplinary research the risk of conflict is greater as there are more inter-organisational relationships and different opinions on the suitable journal.

Trust is particularly important when relationships come under pressure such as when the results are negative for one partner. This can lead to conflicts of interest over whether to release the material and create tensions in the team. In one case there was an agreement amongst all parties not to mention the results for one year as the results were damaging to one party. The results of the second year were not so damaging and so all the results could be released.

3.5.3 The basis of trust – information and sanctions and common norms

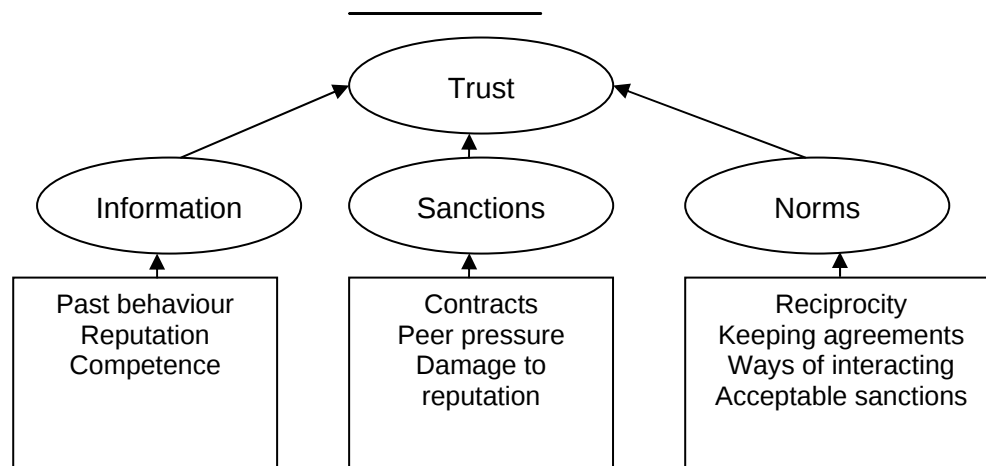
A model of trust is demonstrated in the diagram below with elements of information on others, sanctions on those that do not co-operate and acceptable common norms of behaviour. The information on others refers to knowledge about their past behaviour and reputation (in terms of technical competence, honesty and organizational capacity).

Sanctions and other controls are also important for having trust, a point that is missed by those studies that claim that trust and controls are alternatives. This study shows that trust is based on a element of controls, either formally through contracts or informally through peer pressure: “If they don’t pull their weight you can put pressure on them.We are a group and everyone wants a good project - that’s the pressure” (v.2.168).

In eight of the ten cases, there were formal contracts that held project partners to specific outputs and specific milestones. Other forms of contractual controls include the use of Intellectual property agreements which limits partners’ ability to publish the results for 2 years and a formal publicity plan agreed by all partners.

Less formal forms of sanctions are equally important and include threats to the reputation of an individual if they do not act as expected or act opportunistically. When asked how he knew people would not do as expected, one interviewee stated: “I don’t really know [long pause] – you are contractually obliged and there is this pressure from the whole of the whole of the consortium that if you don’t do the work it can be[pause] The people won’t work with you again and you have a bad reputation.” (v.2.246)

Figure 3.1. Trust production



The quote above demonstrates the hesitation in the reply. This demonstrates the instinctive nature of trust relations with people habitually trusting others as they have sanctions over them (and information on their reputation) that might not be drawn on consciously. From this we can conclude that trust does not necessarily have to be a pure calculation but also includes elements of habits and routines. This supports findings from studies of co-operation in other contexts and cultures (Lyon, 2005).

Common norms include those of reciprocity (helping each other on specific problems and sharing knowledge), keeping to agreements and honesty (for example not publishing material without others' permission). There are also norms of carrying out research. As one junior researcher stated: "It's good because my equivalent person at xxx and I work in similar ways, and we can panic together (laughs)" (v.3.17). In interdisciplinary research new norms may need to be developed to allow people from different disciplinary traditions to work together. One participant of the SAFFIE project found that: "There was an understanding between people because we had all worked on inter-disciplinary studies before. I had done botanical and invertebrate work before especially in link projects" (2.157).

There are also norms that shape what forms of sanctions are appropriate and also norms that limit the ability to exert sanctions. For example in one case where a project partner had broken an agreement, the other partners were not willing to confront them openly as this might jeopardize the rest of the project and damage the reputations of all project team members in the eyes of people outside the project.

3.5.4 Building trust

Trust in research teams can be based on existing relationships, built up over time within the project or through the use of intermediaries who act as guarantors of trust for others.

Existing relationships

For those drawing on existing relationships, they have had the opportunity to learn about how the other party works, their technical capability, their values and through socializing they perceive they are able to put moral pressure on others. Many of the interviewees reflected on networks of researchers doing similar or complementary work, referring to it as a 'small community' where people know of others' work and

approaches. While three respondents stressed that teams could work without prior experience, they recognized that it helps if “you know they can work together”:

“Agricultural research is in effect an incestuous system, everyone knows each other and I got together with other people I knew ... we recognised an opportunity for research.... there appears to be a Mafia of agricultural research, that might be how it appears to the outsiders but in order for a project to work you need a degree of mutual trust and respect if it is going to work and therefore you want people with whom you already have a track record of working” s.4.21

Through working with people known already, researchers can know they can draw on common understandings and norms of doing research and sharing projects

Team changes can threaten the building of trust and this occurred in four of the projects; when someone died, where a partner dropped out as they were not able to do the work, where internal reorganisation meant people were moved away from the project and twice in cases of women taking maternity leave. One interviewee referred to this saying “I suppose you have that sort of noise in any system” (x.3.104)

Existing relationships can also be put under pressure when partners (especially those in the private sector) are perceived to be more of a competitive threat

“Now we are not so popular anymore. So we are finding that all of a sudden people that used to be OK with us because we weren't a threat and now all of a sudden they are not as nice as they used to be. If you become successful people don't like you anymore... for them their market share has been taken.. its straight off their bottom line and someone in [headquarters] is saying 'how can we let this little hick company with one man and his dog take £x million off your bottom line. Somebody is getting some steam from above and that comes out to us” (t.1.7)

Use of intermediaries and guarantors

In two cases (the Wheat Blossom Midge and the Nitrates studies), the project teams came together because of a single person who was known to all parties and who played a key role in facilitating the interaction of the project. In one further project someone was appointed to play the role of project manager and bring the different sides together. These actors play a role in bridging the different parts of the project including the dissemination to practical and academic audiences. In two of the projects, these intermediaries were facilitating the making of decisions about how academic outputs were written up and by whom. In the case study of the Wheat Blossom Midge, team partners commented on the role of one key member:

“it is a very well balanced group of people put together by John and he has done previous work with the others and says there is good synergy there “ (s.2.3c).

Building trust through the project

Through participating in a particular project, trust can be built up. Interviewees reported that trust was built through working together, openness and putting yourself at risk from others, discussing issues democratically, gaining understanding about others' disciplines and having clear and complementary roles. This form of trust building can strengthen existing ties or as one person interviewee stated, it “firms up existing relationships” and:

“It helps to have this working relationship because you need trust but it isn't any problem setting up new ones. With a big project like this and with several groups it does take time for ideas to shake down. We have different ways of working, different

expectations and different ways of writing protocols. People come with their own interests but then over time then the project identity comes as well.....Everyone has to have trust so that they can work to the aims of the project. At the start they all had their own objectives and ambitions but over time, I don't know if I'm being naïve saying this, but you need to establish relationships to work to the benefit of the project as a whole" (v.1. 19,156).

Personalities of team members and power relations were also reported to be important factors: "It hinges on the individual – if you have a good working relationship with people then its smooth but if someone dominates it – normally the older people – then its problems. *Why is it the older people?* They feel they know best about everything..... All the scientists sat around, it was pretty democratic I think and we're after good science at the end of the day. All the people there are post-doc and have the rigorous scientific approach. There was no-one there who was especially senior and trying to push work in their direction." (v.2.79,262)

There can also be a blurring of the lines between working relationships and friendships, with norms of friendship being built up through working and socialising together. In the Home Farm Organic Study, the researchers from different disciplines and research organizations shared a house while collecting data.

There is more opportunity for this in longer term projects, or with continued streams of funding for interdisciplinary research that allows teams to continue working together. For example the two LINK projects involved members who had worked together on previous interdisciplinary LINK projects. However, even after three years of working together on one project, one researcher still felt this was inadequate:

"The task of assembling an interdisciplinary team requires different budgets and timescales. Three to five years is rubbish because the task requires a honeymoon integration period which is a job in itself. It does not happen overnight. In this case it was rank stupidity to stop after three years because we had just started." (1.3.99)

An indicator of trust being built up through a project is the extent to which teams continue to work together afterwards. Where people have good experiences they have been found to be working together on new projects or looking for new opportunities to work together. The collaborative activities of different case study projects after finishing their specific projects are shown in table 3.5 below.

Table 3.5 Relationships after the case study projects

Project	Description	What happened after the project
1. Home Farm Organic Study	Impact of organic farming	Individual researchers did their own project. No funding to take interdisciplinary work forward
2. WildCRU on Chichester plain	Restoring water voles & other species	Follow on project elsewhere using a partnership approach on an even larger scale. Still working with farmers in the area 2.1e
3. Saffie	Agri-environmental measures	Project still operating. Some partners have joined for other projects
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Research team in different parts of CSL have continued to work together
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Relationships with farmers on going
6. Orange Blossom Midge	Identifying resistance & developing traps	Project on-going but partners looking for new opportunities to work together. New project on crop rotations identified by farmers
7. Unilever	Crop and agri-environmental trials	Project is ongoing
8. Nitrates	N Management in Organic farming	Some researchers worked together and one researcher joined the project leader's institution
9. Pig welfare	Developing pig welfare assessment	On going research
10. Biosecurity	Constraints & incentives to biosecurity uptake	New projects carried out with same researchers

3.6 Conclusions

Interdisciplinarity is central to agro-ecosystems research that meets the needs of non research stakeholders who do not follow the disciplinary boundaries of academia. Among the academic community it is widely believed that funding for interdisciplinary research is rare, however, our research on 10 case studies of interdisciplinary research showed that for many of these projects, the demands of those providing research funding was one of the driving forces which encouraged an interdisciplinary approach. The work identified a typology of scientists involved in interdisciplinary research projects. These included technical company scientists, contract researchers, pressure group scientists and university academics. Each had slightly different priorities, agendas and standards. The study showed that the goals of researchers often differed. Commercial technology company scientists will want to have ideas that can be converted into profitable businesses for customers. Pressure group scientists want to disseminate research rapidly via membership newsletters or popular press. More academic researchers may want results to be more rigorously

statistically tested so that they can be disseminated through publication in peer-refereed journals. There are also contract researchers who have specific funding pressures and tight deadlines in which to complete particular projects.

Many spoke of the challenges of bringing interdisciplinary teams together. These included differences in ontological and epistemological heritage, language, the challenge of understanding different disciplinary perspectives of other team members. Setting up research priorities and methodologies was difficult, with several of those interviewed referring to 'design by committee' and projects being 'hijacked' by particular members of the team, either senior sciences, or academic researchers, to meet their particular needs. A big challenge was learning to value the different types of information each discipline might produce, such as natural scientists valuing social science information, and the concerns of those used to quantitative data when qualitative data was used. Agreeing on the final conclusions to be drawn from projects was also difficult, with people referring to 'science by consensus'.

Another outcome of this research was a clear indication of how important it is to develop a team that can work together. In each of the cases, issues of co-operation were based on interpersonal trust. Trust was found to be shaped by issues of information on others, sanctions and common norms. The information on others concerned their reliability and the expectation that they will act as expected and came from existing relationships, from intermediaries, or is built up through working together. Trust is also based on having potential sanctions over them, either through contractual controls, but, most importantly for the teams examined, in terms of peer pressure. These relations are also underpinned by a set of norms concerning reciprocity, what is considered honest behaviour, and use of each other's knowledge. In some cases, key people played the role of intermediary, bringing together researchers or institutions which might not have worked together without the presence of a guarantor.

Towards the end of projects, researchers have had to overcome difficult decisions concerning where and how to publish results. Some want peer-reviewed articles in journals, others more widely-distributed, easily understood outputs for farmers, businesses or the wider public. Agreement on the level of robustness of the information, as well as the venue for publication, caused concern in some projects.

Part 4: Scientist involvement with farmers in interdisciplinary agro-ecosystems research

4.1 Introduction

While the scientific method has led to considerable advances, for many researchers the quality of research is judged according to 'internal criteria' such as publications and peer review, rather than on external achievement and end user satisfaction (Pretty and Chambers, 1994). Thus, scientific communities have ensured that much agricultural research has been carried out on agricultural research stations, environments of known field history and relative uniformity. Rather than tackle variability and complexity of farming systems, scientists tend to concentrate their research on those areas that yield to the reductionist method and work well under laboratory or controlled conditions (Knorr-Cetina, 1981:2).

Pretty and Chambers (1994: 195) and Robinson et al (1997), drawing on their experience of participatory research in less developed countries and Australia respectively found that involving farmers in research requires attitudinal changes such as breaking the stereotypes that scientists are talkers and farmers are listeners. Institutional barriers for scientists to work with farmers include the existing incentive system such as the need for many researchers to publish research in peer reviewed journals. Reviews of those organizations that have been able to make changes towards more participatory methods attribute their success to changes in the reward and incentive systems (Martin and Sherrington, 1997; Robinson et al, 1997; Baur and Kradi, 2001). Based on previous research on the role of farmer participatory research these projects can be classified under different types of participation as shown in figure 4.1.

Figure 4.1. Participatory research approaches – A continuum

	Researcher managed and implemented	Researcher managed and farmer implemented	Farmer managed and implemented
	Contractual	Consultative Collaborative	Collegial Co-learning
Location	On station or on farm	On farm	On farm
Design	Researchers design trial and control all treatments. Farmers rent or donate land	Joint design and selection of criteria. Farmers encouraged to use controls and replicates.	Farmers or advisors decide on trial design and evaluation criteria. Hypotheses may evolve out of chance events and change during the season.
Methods of data collection	Researchers control all measurements. Farmers invited to offer their opinion	Researchers collect what quantitative data they can and get farmers' opinions through interviewing	Researchers document farmers'/advisors' evaluation/reflections at certain points during the season.
Methods of analysis	Careful use of statistics (Sherrington and Martin, 1997).	Statistics combined with qualitative assessments of farmers' views	Results of measurements with attention to paid to the establishment/growing conditions
Dissemination	Researchers disseminate results to farmers and advisors	Iterative through on-going interaction of farmer and scientist	Farmer to farmer with external input to encourage networking sharing of experiences

(Source: Biggs, 1989; Norman, 1998; Okali et al, 1994; Lyon, 1996)

The cases selected were chosen to demonstrate a range of types of farmer interaction with scientists in research projects. These types of involvement are shown in table 4.1 and can be shown to have differing degrees of farmer involvement in terms of setting the overall research questions, design of the treatments, and evaluating or interpreting the results.

Table 4.1: Types of farmer and other land user involvement in each case study project

Project	Description	Types of land user involvement
1. Home Farm Organic Study	Impact of organic farming	Farm owner initiated study, farm manager allowed researchers to examine his practices. Steering group involved people from organic movement
2. WildCRU on Chichester plain	Restoring water voles & other species	Farmers allowed researchers to monitor and were encouraged to try new treatments. Managers of nature reserves and farm advisor involved in design and data collection
3. Saffie	Agri-environmental measures	Farmers on steering board advise on practicalities of treatments. Farmers on monitoring sites give feedback on problems of specific treatments.
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Farmers selected options and researchers collected views on the process of applying
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Farmers consulted through the 'Buster club' and are given samples of developing varieties to try out
6. Orange Blossom Midge	Identifying resistance & developing traps	Farmers try out pheromone traps on land
7. Unilever	Crop and agri-environmental trials for sustainability	Farmer forum identifies research, research undertaken on a farm under commercial conditions
8. Nitrates	N Management in Organic farming	Farmers practices are recorded and farmers involved in interpreting the results at a workshop
9. Pig welfare	Developing pig welfare assessment	Farmers give their opinions on issues of welfare and 'what makes for a happy pig'
10. Biosecurity	Constraints & incentives to biosecurity uptake	Farmers involved in focus groups

4.2 Farmers involved in the design of the research question

In four of the cases, farmers were involved in setting the research question, either through being on project steering boards, or through sharing their ideas with researchers.

The Unilever Sustainable Agriculture programme uses farmer groups and a Farmer Forum to feed ideas for the objectives of the research.

"We use a pilot group of 19 farmers to set some of the questions and now we also have the farmers' forum. We have a planning meeting and we also have research partners there and we use it to put forward ideas and ask the farmers if they think it's worth doing and if they think it's feasible. We need to know that. Eg We are looking at cover crops which could be important and will be one option for nitrate leaching mitigation but we are interested in what the growers are thinking because its just more hassle for them and not much specific benefit to them except it does lock in the nitrogen.... Out of the 19 farmers you might get half of them. It's often the same ones. If it's good weather then lots of them will drop out on the day but there is a core group of enthusiastic people. But that's different to the xxx group – there there are 8 growers who are paid – we feel that's important because it helps to engender their commitment" (4.79,91).

"I got these people to talk to 15 focus groups of farmers, both local and beyond. I think once you start this you get a germ of an idea and then it spreads. And none of this has been with any funding with DEFRA or anyone else but we're bringing people like HGCA and DEFRA here, so we plant a seed of an idea with the funders and then we also bring farmers as well in here at that same meeting as a reality check." (3.66). The company values the input of the farmers as it allows the farmers to be involved and feel some ownership of research leading to future recommendations from Birdseye/Unilever for pea production.

Farmers' ideas can also be fed in informally where scientists engage with farmers regularly and get ideas from these conversations. Two of the interviewees of the Wheat Blossom midge project referred to the role of farmers in initiating the research.

Other land users can also be involved in the research design, such as the role of managers of nature reserves and flood defense officials in the WildCRU case study: "It also came out of a chance conversation with the manager of a nature reserve who wanted to know how the water voles in his reserve were linked to farmland and what they were using," (2.1.20). Advisors can also play a role in designing the research and in this case, the experiential learning and informal research carried out by a FWAG advisor was incorporated into the design of the research and used in the interpretation at the end. This is a rare example of where farmers' or advisors' own experimentation can be combined with scientific approaches.

One farmer complained about the unequal power relations that can limit the ability of farmers to interact with scientists: . "We sat around the table, with professors and PhDs and when I mentioned anything off the beaten track they just..... they wanted to do research on their own topics. ... I used to bleat mildly, but now I would make more fuss. Then I was sitting there with all these high powered people".

Although other researchers reflecting on the project valued his input of advising on practicalities of treatments:

"Farmers were involved in xxxxx and there was quite active participation and the farmers would say why are we doing this and that or that's bloody silly so that sort of dialogue shapes the work but I can't remember the exact details" (x.3.95).

In four of the cases, farmers were involved in steering committees for research although the extent to which they had an impact on the research agenda varied. One

farmer was on the steering group of one of the organisations carrying out the research but felt powerless as research was “driven by budgets and funding”:

4.3 Farmers decide on manipulations

In the WildCRU study, farmers were involved in the design of the specific treatments on their farm. In this case the design of the field margins was carried out jointly by the farmer and the Farming and Wildlife Advisory Group advisor. In this way the research was also able to tap into farmers' knowledge of water flows:

“Farmers were very useful in explaining about the water in the ditches and we might suggest that they should try and flood ditches in summer and they would tell us it was impossible in some cases as they had local knowledge and knew where the water flowed. They also would know where their grandfather put in their drains, they might even have maps showing where the drains were. They are the guys on the ground, they know how the land performs in different weather” (w.1.218).

The pilot study of the entry level scheme also allowed farmers to select measures and then assessed the process of applying for the funding and installing the agri-environmental measures. Advisors from DEFRA learnt through documenting the reasons why farmers joined, what options they chose, which ones they did not choose, the questions that farmers were asking and how they interpreted what a particular option meant. One farmer involved pointed out a number of areas where his assessment had been noted:

4.4 Farmer involvement in evaluation

Although several projects conducted experiments on farms, the input of the farmer was generally minimal. Farmers were only asked to take measurements or collect data in one case as this was considered to be too time consuming. Their practical input usually extended to managing a margin, field or several fields in a certain way as, for example, in the SAFFIE project. If farmers were interested, it may be possible to get them to collect data, saving researchers time and money. However, a farmer involved in the VEERU biosecurity project and the ADAS expert group project thought that this would depend on the farmer. In the WildCRU case farmers were involved to a small degree through joining volunteering groups that were collecting data on biodiversity.

The only case where farmers were involved in formal evaluation measures was the Wheat Blossom Midge project

Farmers were asked to monitor the extent of Wheat Blossom Midges using an innovative approach whereby farmers were actually paying to be involved:

“In year 2 we took prototypes to meetings and asked the farmers to take them away. It was really low-grade participation. Last year we did a test marketing exercise. We approached it 2 ways. We went to farmers where they have traps for an on-farm calibration exercise. We were also selling some and asked for feedback on the performance. The HGCA did a mailing on the traps and we managed to sell 200 sets of traps. This year we are selling 2000. The farmers buy the traps and send the forms back. We made some modifications to the traps as a result of the feedback last year. For example, we put a grid on the sticky trap so the midges were easier to count. We have also now produced a leaflet that will be sent out with the traps that will hopefully answer any questions farmers have and show the best way of using them.” (3.35)

The perception of the researcher that this is “low grade participation”, raises interesting insights into how researchers consider appropriate participation by farmers. There are limitations on farmer involvement particularly in terms of their time and as one farmer stated: “It’s difficult juggling it with normal work though. If the research is on individual farms and the farmers are taking measurements the diligence of the farmers has to be very good. My diligence is very bad. Its alright when the researcher is there filling in the forms but when I have to fill it in myself the columns remain blank. I think it has to be very simple unless the scientists are doing the measurements” (q.5.3).

Other projects collect the views of farmers through qualitative surveys of the treatments being carried out on their farms. In the SAFFIE project, the ADAS advisors are used to collect this information for the farms on which treatments are being monitored. While this division of responsibility allows for rigorous data collection, some research scientists have found that they have not had much engagement with farmers in this project. The farmer comments have been important in identifying weed pressure on skylark patches and resulted in a change in recommendation.

The Nitrates case study project demonstrates alternative ways of involving farmers in analysis. Following the data collection by researchers the results were presented to the participating organic farmers in a workshop environment where they could discuss the results. The location of the meeting was carefully chosen at a venue where farmers felt comfortable (Elm Farm Research Centre) and farmers were keen to discuss results specific to their farm, while also drawing on their competitive streak and desire to find out about other farms. Farmers made comments on the recommendations and practicalities of carrying out different manure management strategies.

Informal feedback from farmers was found in most cases and occurs through general conversations with farmers. All farmers who have offered to have research carried out on their land are likely to have a view on the results but it depends on the approach of the researcher, whether they are asked and whether this information is then fed into the research project.

This source of informal feedback is the primary objective of the Buster Club set up by Nickersons plant breeders and Brown & Co (farm consultants) and a group of farmers. It originated after a visit of 12 farmers and in the pub afterwards they decided to form the club. The farmers were also keen to get more information about specific varieties, especially those that Nickersons were developing that were lower yielding but having lower costs. It meets four times a year to discuss farmers’ needs, their views of Nickersons varieties and the varieties of their competitors. Following this interaction, Nickersons were persuaded to develop disease resistant varieties that reduced the need for agrochemicals. “We all listen to each other ..., it is a good chance to have a conversation and develop trust, get new ideas”. One of the participants stated: “Bill [the Managing Director of Nickersons] knows things in theory but in practice, for example, what happens if you have to spray late, and is it more susceptible to a particular disease? I think Bill has gained because of the group of farmers he can talk to and he can hear about the downside of things. The objectives are also to bring growers and end users together so that you could also have good quality produce and do well for the farmers. Members get access to new varieties early” (2.56)

Through this consultation, the breeders are able to tap into the farmers’ knowledge and understanding of balancing multiple criteria and making holistic assessments: I think they get our comments on their competitors’ varieties. They also know what we

are looking for, the yield, whether we want straw or not or quality. You can get a bit confused with all these different issues because every farm wants something different but if you are careful you can get some ideas from it" (4.69).

There are no formal data collection procedures but the knowledge gathered by the plant breeders feeds into their tacit knowledge. One of the plant breeders stated "I get feedback from them about what they are looking for ...and if they are not interested in xxxx that goes into your brain and you think 'I know where to go on that one' "(1.10). Similarly, Richard Levin at Brown & Co who helps organise the group stated: "I think it is lots of raw data going straight to Bill and Ron's heads. This feedback is very important and you can't really quantify that sort of thing. They can also give feedback to farmers. I think this works and you can overcomplicate things" (2.82).

The use of farmers' holistic assessments and knowledge was also found in the case study on animal welfare carried out by SAC: "They listened to our opinions when they came to visit to do the assessment. They listened to what we thought were signs of a happy pig." (2.79). In this way researchers are able to tap into how farmers balance multiple assessments and use different criteria (as discussed in part 2 of the report).

4.5 Researchers examine farmers' practices

In seven of the 10 cases, the farmer involvement in research involved researchers monitoring farmers' existing or new practices, thereby seeing the farm as an experimental site. This allows researchers to look at the whole farm scale, look at treatments over a very large area or with much variability but with no costs of setting up an experiment, and to make observations in a commercial setting. One farmer on a steering group stated that "we were keen to have real live commercial farms participating if possible because it's very hard to replicate the results from a research farm... it had to be practical and based on real farms." (o.2.3).

In some cases farmers let researchers observe their existing practices while in other cases they were encouraged to put in place specific treatments that could be monitored over time. For example the WildCRU project introduced a range of treatments that the farmer did not have to pay for: "We tried different things like for water levels. Farmers let us have a bit of a play with bunds and ponds and we surveyed later" (w.2.e).

Farmer involvement varied from being consulted on their views to less intensive approaches where they "tolerate" researchers and "put up with twerps prancing through crops" (x.3.92). One researcher referred to "talking to" farmers, implying a one way flow of knowledge and another stated that they had no time to talk to farmers or build up a relationship with them. In such cases, the research emphasizes the natural and biophysical parts of the agro-ecosystem rather than the economic and social aspects. In other projects, farmer interviews were important parts of understanding what was happening, the history of fields and other problems.

4.6 Recruiting farmers

The relationship between researchers and farmers was identified as an important factor by many interviewees. As with the relationships between researchers, trust is

an issue in the relationships with farmers as both sides have to make themselves vulnerable and there is a need for clear expectations from both parties.

Farmers need to know they will benefit or face any negative consequences such as the costs of putting in treatments or the use of farmers' time. In all cases, the farmers involved in the case study research were acting on an element of altruism and benevolence. In such cases, they recognize the risk that they are wasting their time if the research will not lead to useful outputs at the end. In one case, the farmer reflected on the loss of trust as he felt the research was a 'jolly' and that the research had not been written up properly.

The WildCRU study identified the issue of 'farmer fatigue' if there are not clear outputs aimed at farmers such as leaflets using non technical language and the use of media to give farmers publicity in the local press:

"I think there is a danger of fatigue amongst landowners especially when people come on to the land and do not report back so it is very important to say whether numbers have gone up of water voles or skylarks, and it keeps them interested. It is easy for us to get so wrapped up in the science that we do not give them feedback."

Risks of being involved with research was found to be greater amongst livestock and dairy farmers as they have concerns over what might be found by the research. The researcher on animal welfare said "I went to see the farmers on their own first to assure them that there would be no records naming their farm" although one farmer who did participate noted "Other people in the area were astounded that I'd let that many vets on the farm" (2.76). One interviewee noted: "The work with farmers found it is hard to persuade the farmers and there are other complications, like. if they find salmonella then they have to report it but farmers don't want to be identified as having either a disease or a disease agent on their farm" (0.3.2).

Trust was identified by Unilever staff, although this research was not able to explore how these relationships were viewed by Bird's Eye pea farmers:

"This sort of research works here because Unilever has a long history of working with the farmers. We meet them often and build the relationships up with them. There's a fair bit of trust on both sides and for the farm its important we [Unilever] take their interests on board and they can then realise how they can benefit. The relationship with farmers is important – they must be happy that the research will not cause them any more trouble, like a few years ago we asked farmers to look at nitrogen after peas but one farm was very reluctant and would not say why but through Chinese whispers we found out that he felt that if we could show that he saved money then Unilever would reduce the price. You always get those sort of people." (4.203)

Trust can either be built up or drawn from previous relationships. The case study on animal welfare worked with farmers who had been involved in previous studies with the main researcher, while the study on disease controls in dairies built up trust over interacting with the farmers during the project:

"I visited the farms every 3 months so I could check if the farmer records were correct and could see the vet bills, what methods were being used. For 2 years I had close relationships with the farmers and they learnt to trust you and I would spend time with them. I would spend 2 hours in the milking pit and I used to chat and find out lots of things" (1.7).

Trust can also be drawn on through intermediaries who know farmers already. This is discussed in detail below, although in the WildCRU study and in the Evaluation of the Entry Level Scheme pilot project, a farmer was used to recruit other neighbouring farmers through hosting farm walks.

“We found that farmers were very interested once we had broken the ice and at farm walks farmers come up and said how at the beginning they weren’t sure what we were doing but then they saw how one can use the water vole as an indicator species. At the beginning, at the earliest stage, it was all about ‘cold sell’. We would be ringing them up but then once we had a few contacts we could ask them to ask their neighbours to come and see what they were doing” (w.1.32).

Trust is a two way process and researchers may also have to have trust in the farmers so that they can discuss failures honestly or ask the farmers about novel recommendations. In one case researchers wanted to show a group of farmers an unsuccessful trial and this ended up dominating the day’s discussion despite the farmers being shown many other things. Many researchers demonstrate an element of fear of farmers and their criticism of the relevance of their research..

“Farmers could pull the research team to pieces if they wanted to... Funnily it was xxx who said that he felt he was coming to the lion’s den to defend his work, he was a bit worried about it....farmers can be as harsh as any editor” (q.1.9).

4.7 Bridging the farmer-scientist gaps

While this study has noted many of the difficulties for farmers and scientists working together, it has also identified a range of ‘boundary spanners’ who can understand the needs of both farmers and researchers and the interactions in agro-ecosystems.

The role of these individuals in each of the case studies is shown in the table below and can be divided into three groups:

- Private sector scientists who want to be close to their customers and understand their market
- Scientists who have personal links with farming, predominantly through their parents
- Specialist ‘boundary spanners’ who are brought into a project specifically to work with farmers

Three of the projects selected had major involvement from the private sector in terms of personnel and funding (Nickersons plant breeding, Wheat Blossom Midge and Unilever). It is interesting to note that in these cases the scientists from the private sector appeared to be more involved in direct interactions with farmers as it was perceived to be important for understanding their commercial market and important for building their reputation with growers.

Family links to farming were cited by interviewees in four of the case studies. One research project manager was brought up on a dairy farm, another is the son of a farmer, one is married to the daughter of a farmer and one is the son of a farm animal vet. These links were given as a reason for these scientists to take more of an interest in farmers’ views in their careers than might otherwise be the case and their ability to communicate: “he can talk farmers’ language and that is important” (t.4.50).

Those projects that have involved ‘boundary spanners’ from the start to engage with farmers recognize the skills that are required and the time it can take building relationships. These tend to be agricultural advisers or researchers with experience of working with farmers and persuading them to be involved. Advisors in two of the projects were also involved in advising on the design of the research because of their knowledge of what is practical in a commercial farm environment.

Table 4.2 Ways of bridging the farmer scientist gap in each case study project

Project	Description	Bridging the scientist –farmer gap
1. Home Farm Organic Study	Impact of organic farming	Steering group included people from the organic movement. Farm manager advised scientists on practicalities
2. WildCRU on Chichester plain	Restoring water voles & other species	FWAG farm advisor involved all through the project
3. Saffie	Agri-environmental measures	ADAS advisory staff asked to make links to farmers. Some researchers have personal interest in farming as family members are farmers.
4. Entry level Scheme	Evaluation of the entry level scheme pilot	Used DEFRA staff to advise farmers on agri-environmental options and used a researcher with lots of experience of collecting data from farmers
5. Nickersons/ Brown & Co and the Buster Club	Wheat breeding	Work with a Brown & Co (farm consultants) who organises the farmers. Key scientist has excellent rapport with farmers and background to farming as his father was a vet. He recognizes the commercial need to get farmer feedback.
6. Orange Blossom Midge	Identifying resistance & developing traps	Scientists involved who like lots of interaction with farmers, use advisors to work with farmers
7. Unilever	Crop and agri-environmental trials for sustainability	Farm manager on research farm and field staff who work with pea growers
8. Nitrates	N Management in Organic farming	Researcher with farmer links brought into the project
9. Pig welfare	Developing pig welfare assessment	Researcher had good experience of working with farmers
10. Biosecurity	Constraints & incentives to biosecurity uptake	Use of consultant and main researcher comes from a dairy farming family

The case study on bio-security wanted to arrange focus groups and so used dairy consultants who had established groups of farmers who knew each other already and could encourage good interaction and involvement, and manage the groups so they were not dominated by particular individuals who might be trying to push the specific line of an organisation they represent (1.3). Nickersons worked with farm consultants to organize the Buster Club with the farm consultants benefiting from offering a service to existing customer and attracting new clients.

Other projects brought in farm consultants to collect data from individual farmers such as doing daily counts of midges on farms for the Wheat Blossom Midge project, to collect farmers' views of environmental measures for the SAFFIE project or to help farmers start agri-environmental measures in the WildCRU study and the Unilever case.

These boundary spanners have also been used for the dissemination of results. For example, advisors were used as a dissemination route to inform farmers of the results of the project (Table 4.2). For example, Ben Freer of TAG was involved in the Orange Wheat Blossom Midge Project:

“What I enjoy is the dissemination and explaining complicated and high science results into farmer speak.... this is not a matter of dumbing down but turning it into language they would understand. I enjoy being in the project; it is nice to get to hear about and be involved in these scientific breakthroughs and that the role at Morley, in between both high science research and the farmers, gives that chance to be involved in new scientific breakthroughs and hear about them and pass it on.” (4.173)

Researchers with good links to farmers can also be used for linking other researchers with farmers and they have the added benefit of having a deeper understanding the needs of scientists as well as those of farmers. While involvement of these specialists can be beneficial, it was also noted that this division of responsibility can result in scientific researchers being even further removed and distant from farmers

In the Nitrates in organic farms case study, the researcher involved to recruit farmers stated:

“The other researchers had not worked with organic farms before or had no contact with the farmers. I had that relationship with the farmers so I was not cold calling them or wanting to get them involved.... I acted as the farmer liaison because I can see both sides of the equation and I think this ironed out possible tensions and conflicts. Also we were using case study farmers when there was already lots of information on what they were doing. I can really understand the difficulty some of these researchers have, because I started doing work doing research in a controlled environment and then when I moved to the field and found I could not control all the variables I found that really hard and so now I am very sympathetic with researchers. .. I know their grounding and what excites them (1.1,6).

Another team member noted the role of this person: “she was pretty critical. She also identified appropriate farmers and helped set the appropriate questions and made sure we didn’t ask silly questions. She was the most practical of all the experts and she made sure we did not come across as being out of touch.” (3.5)

Respect for farmers’ knowledge and ability to listen were given as a key attributes of researchers working closely with farmers.

“There are a certain type [of scientist] that can work with farmers. Rob for example understands land management and gets out on the ground. If you want to get a message to farmers you have to be careful. There are some scientists I would not want to work with or walk round a farms with. Rob’s attitude helped – its something we need – get people on farms and get involved. It is partly Rob’s background being at WildCRU and the Environment Agency... Can we create more like him? I don’t know.” (w.2.h)

As mentioned earlier, some academic researchers are perceived to be more distant from farmers and lack an understanding of commercial farming and the needs of land users. In five of the case studies, farmers had changed treatments either by accident or commercial necessity during the study. While some researchers accepted this as the unpredictability of carrying out research on a ‘working farm with the farmer carrying as normal’, others were less understanding.

4.8 Statistical rigour and participatory research

The reduction in control that researchers have over research when farmers are involved results in a specific challenge for agricultural scientists trying to implement statistically rigorous methodologies within the diversity and complexity of on-farm farmer participatory research.

Riley and Alexander (1997) found that in participatory research statistical methodology was often poorly defined and inadequately used, evidenced by inadequate sampling and confounding of effects. They concluded that although work on statistical methodology was available for use with on-farm participatory studies, it was not necessarily in a form easily used by non-statisticians (Riley and Alexander, 1997).

Discussions on statistics in farmer participatory research has generally been carried out in the context of projects that are carried out in developing countries (Anon, 1998; Ashby, 1986; Martin & Sherington, 1997; Riley, 1996), although a recent report has assessed the organisation of the Farm Scale Evaluation (FSE), a large on-farm research project in the UK looking at the effects of GM crops (Archer *et al.*, 2004).

On-farm research may be multidisciplinary, managed by farmers, lengthy and be subject to greater variability in material and data unless objectives are altered through the project (Riley, 1996). During the FSEs, statisticians were employed at this stage and their contribution was considered essential (Archer *et al.*, 2004). For example, during the pilot year there was an investigation into the appropriateness of split or paired fields (Archer *et al.*, 2004). However, the cases in this project show that attempts at selecting random farms is rarely possible as recruiting farmers is difficult. Recruitment was found to be especially difficult for contentious research such as the GM trials.

Case studies carrying out statistical analysis reported that a good experimental design was crucial in order for the data to be analysed and effects detected. A design with sufficient replication is very important in any experiment that is to be analysed statistically, and since on-farm research is inherently more variable than experiments under more controlled environments a large number of replicates were required.

In order to determine the optimum number of farms, in statistical terms, to be used, a power analysis was carried out by one of the researchers in the SAFFIE project. The power of a design is the probability that a treatment effect of a specific size will be detected when the data is analysed, and it depends on likely variation and the number of replicates. Detailed power analysis was carried out during the GM trials. It was calculated that 60 sites for each of the crops being investigated would be required over 3 years and more were added to take account of potential losses (Archer *et al.*, 2004).

However, despite this calculation, some projects were still not able to achieve the desired replication because of practical problems in recruiting and retaining farmers. Furthermore, the problem most frequently mentioned about farmer participatory research was that of farmers not carrying out the management of the land involved in the project as the researchers had asked. In such cases, researchers have to hand over an element of control to farmers, changing the power dynamics between the parties. This issue came up as when talking to researchers involved in the SAFFIE project, the Chichester Coastal Plain Sustainable Farming Partnership, the Home

Farm Organic Study, the ADAS Expert Group project and the Birdseye Unilever Sustainable farming project. A selection of the comments that were made are shown below:

“Things always come up because farmers are not doing as they are told or they forget to do something. So this way we lose sites out of the studies and we lose the replication” (v.7.108)

The case of the WildCRU study on the Chichester plains realised that they had to accept a level of uncertainty as “there are hiccoughs but because of the large number of sites it is not a problem” (1. 117):

“When it’s at a farm scale it has to be highly replicated to be very robust but there are there very frequent and ghastly situations when a treatment is sprayed out. It’s usually down to the bad memory of farmers and their uncontrollability so you need to keep reminding them about what we’re doing and to make sure farmers realise. Now we are better at it On a practical level it is very difficult to implement research on working farms so you need the replicates and also the sample size to get the statistical power. The result is always ... With this sort of work we find we can publish in the grey literature. But now we’re trying to publish in the black and white. But in this highly collaborative work in the real world, then there is less control than you would have if it was an academic study.....A related issue is the expenses because if you’re doing it at a farm scale or several farms then you need hefty management” (w.3. 49)

The quotes demonstrate how trials may be one of many other activities for farmers and may not be a priority. The level of participation is also shaped by the farmers’ relationship to the researchers and this can be affected by a wide range of factors. For example, one farmer with trials on his land carried out by the buyer of his crop was upset by how he was being treated by the large firm and decided to drop out of the trial:

“Sometimes it is hard, like on the margin trial, where we didn’t spray the edge of the field. One farmer got very fed up, I think because of other factors like harvesting issues, so he sprayed it all out. It does happen but on the whole farmers are very co-operative” (r.4.73).

Sometimes this problem is unavoidable as being flexible and responding to uncontrolled environments is a central part of farming systems. For example if weather conditions may prevent farmers carrying out a task:

“There is potential clash of what we want to do as scientist and what farmers want as farmers, then we also have the weather that messes things up. For example last august there was real trouble getting the winter crop in’ (v.7.69).

Reforms to the Common Agricultural Policy also affected how farmers manage rotations with many stopping growing second wheats part way through the experiment examining different rotations. Another problem farmers encountered that prevented them carrying out the right management for the project was pest or disease problems:

“We also found that one farmer had a complete loss of a crop because of slugs and so he ripped it up and planted something else and therefore changed the rotation. But you just have to live with this” (v.1.145-148).

One farmer also identified the difficulties of scientific research to carry out relevant studies because of the variability of farming systems based on a large number of interlinked factors: "I think research is quite difficult because everyone has their own dairy farm, the way they run it is different, the percentage of crops varies and there are different problems associated with each one." (q.5.4)

It was reported that in five of the ten cases examined, researchers had problems with the management of trial sites. Statisticians in one project stated that this should be taken into account when determining how many farms (replicates) should be used. A statistician involved in one project said that:

"The design of the experiment needs to be put together to take account of these issues. There should be a certain amount of redundancy built in. This allows for a certain amount of failure by the farmers so you still have enough samples at the end" (v.8 42-44).

In the case of one project, each institution involved was collecting and analysing their own dataset separately at the beginning of the project and statisticians had not been involved when the project had been initiated and the design decided upon. One of the statisticians brought into the project later thought that this was a mistake and that the analysis could have been simpler if a statistician was involved from the beginning, there were common data sets and statistical advice had been costed into the proposal from the start.

"The problem with coming in late to a project is that the collection procedures and protocols have already been started. This meant that the type of analysis that was carried out had to be more complex than would have been necessary if a statistician had been involved from the beginning. It also means that explaining the results is more difficult, especially to a layman" (v.8.20-25).

Another issue with on-farm research that was encountered was that often the farms involved were spread over a wide area, sometimes the whole country. When studying subjects such as biodiversity this may have a large effect on results since different species are more abundant in some areas than others. This issue was overcome when looking at bird populations in the Home Farm Organic Study. Here each organic farm was paired with a nearby conventional farm for comparison of bird populations between organic and conventional farming systems. Then, in the analysis, farm pair was included as a covariate to control geographical variation (Chamberlain *et al.*, 1999).

Experiments had to be statistically rigorous to satisfy the requirements of the funder, the institution of the researchers and for any publications that may result from the work. However, the work was often carried out on farmers' land and was designed to benefit farmers who often either do not understand statistical analysis or do not think that it is an important aspect of the project. When one farmer involved in the Birdseye Unilever Sustainable Farming Project was asked his view of applying statistics to sets of results, he said:

"Oh that topic! If you talk to a farming audience not one farmer would say that statistical significance is important but that's because they expect others to do it - so to allay their fears we feel we should do it but then if we only tell them about things that are statistically significant then we've only be able to tell them very few things." (3.173).

4.9 Conclusions

Each of the cases have involved farmers and other stakeholders in different ways in their research. In this way, the projects are different from much other research that has less involvement of farmers or other end users. In some, farmers are involved in problem identification, in others, in implementing treatments. In only one case were farmers involved in evaluating the results.

There can be a tension between applied research that is directly relevant for farmers and other that has other researchers as their primary audience. On-farm research is necessarily less controlled than that which occurs on research stations or within the confines of laboratories. When farmers (rather than researchers) are involved in implementing treatments, managing trials and evaluating results, the degree of variation is further increased. This presented particular challenges to researchers seeking statistically robust results. The difficulties of ensuring statistical rigour when working with farmers was mentioned by four of the cases. Specific statistical advice was found to be used to identify of the number of farms required to provide statistically robust results, as well as guidance on experimental layout. However, researchers needed to take into consideration the priorities of farmers. Alongside their involvement in a research project, farmers are still running a business and may not prioritise research related treatments, or inadvertently change treatments. Researchers with experience of these constraints made allowances for the loss of experimental sites in the original statistical design of their work.

Farmer participatory research was not found to be cheaper or quicker. Rather than investing in equipment and experiments, it required considerable staff time to develop relationships with farmers and other researchers. Several of the projects stated that they were under-costed. However, a benefit of farmer-participatory research was the close links between farmers' views and suggestions, and implementation of further research or business ideas. Key people, acting as boundary spanners, facilitated this process.

The issue of power relations between farmers and researchers was evident in the different types of participation. There was very little use of farmers own research and learning and researchers find it difficult to meet the needs of funders and their research community, while handing over control for treatments to farmers who may be less concerned about changing treatments during the research process and statistical rigour.

These projects have demonstrated different ways of reducing the tensions and finding ways of working together. A respect for farmers' commitments was found to be central. Farmers, operate at the whole farm system level, not focused on one particular research topic. Therefore researchers needed to be prepared to think more widely than specific project focus, show respect for farmers' commitments, take into consideration the demands the project is making on normal farming practices, and the timing of research work in relation to their work calendar.

The issue of trust was again raised as an important issue allowing co-operation. There is a need for farmers to trust that the researchers will work as expected and for researches to trust that farmers will co-operate. A key role was played by individuals who acted as boundary spanners with an understanding of the needs of both farmers and scientists, bringing disparate groups together and, ensuring clear communication.

Part 5: Overall Conclusions

This study has explored how farmers and scientists operate in the context of trying to understand agro-ecosystems. This is shown to necessitate taking an interdisciplinary approach as well as a trans-disciplinary approach that includes the participation of farmers and other stakeholders whose activities are not framed by the boundaries of academic disciplines. The findings of the research have considerable implications for academic research in the social and natural sciences, and implications for policy makers, non governmental organisations, farm advisors, and farmers.

The specific lessons coming out of this research include:

- The need to ensure good communication and team building between researchers and with farmers. This takes time and is often not costed into research proposal. Short term funding also limits these relationships.
- Farmers' own research and holistic assessments of technologies and practices can make a vital contribution to knowledge production although its approach can be very different to scientific method
- Farmers and different types of scientists have differing agendas that have to be negotiated.
- The ability of some researchers to participate in interdisciplinary participatory research can be limited by institutional pressures (such as the need to publish in academic journals) unless there are alternative incentives.
- Boundary spanners who have an understanding of the needs of scientists and farmers may be required to facilitate the development of relationships and act as guarantors to build up trust between actors in the research process
- For statistical research, the selection of sites should take into consideration the likely loss of some sites from the research due to the uncertainties of farming. Statistical advice should be sought from the start.

In terms of theoretical contributions, the findings present insights into the process of inter-disciplinarity and trans-disciplinarity. The study of farmers' own research found that while formal science has to ignore local complexity in order to generate a technology for a wide recommendation domain, farmers' research is based on local complexity, with farmers having to cope with many conflicting demands. Their knowledge production may be conscious or more habitual and based on building up tacit knowledge. It also identified the key role for networking amongst other farmers and of advisers in fueling this learning and acting as a form of evaluation.

The process of carrying out interdisciplinary research is shown to be dependent on a range of relationships that are shaped by both power and trust. Three are challenges of bringing disciplines together, although funders were found to be important factors in encouraging people to work across the disciplinary boundaries. There are other boundaries observed in terms of the different types of researchers and their institutions. These include technology company scientists, contract research scientists, pressure groups scientists, and university academics, each of which have differing priorities and motivations. The research found elements of competition between and among types of researchers with power relations based on access to funding and information shaping the negotiations researchers have to go through to build up inter-institutional teams.

The issue of trust was also central to these relationships with people drawing on existing relationships, building trust up through working relationships or using intermediaries who are known to all parties and act as guarantors. These relations are also underpinned by a set of norms concerning reciprocity, what is considered

honest behaviour, and use of each other's knowledge. Trust is based on having information on the parties concerning their reliability and the expectation that they will act as expected. It is also based on the ability to have sanctions on them, either through contractual controls, but most importantly for the teams examined, in terms of peer pressure.

The interaction with farmers results in a range of other relationships. There is a need for farmers to trust that the researchers will work as expected and for researchers to trust that farmers will co-operate. The project found that there are degrees of farmer participation with differences in the extent to which researchers hand over power to the farmer in terms of the design and evaluation of the experiment or research. Relinquishing power was found to be in conflict with the need to have statistically rigorous research as farmers may not ensure that treatments remain unchanged through the research. Where there is more farmer involvement, the interaction with researchers is found to be more informal with feedback on technology or processes that may not be published but feeds into the 'tacit knowledge' being acquired by researchers. This form of research was found to be more common in private sector researchers.

This research project itself has been an experiment in interdisciplinary research. The design of the research was carried out by people from different disciplines and interviews and the analysis were done by a social and a natural scientist. Like other research projects, the collaboration was able to draw on previous working relationships and continued despite a change of team member at the start. The interdisciplinary experience has resulted in social scientists learning about the process of natural science research and natural scientists understanding how research is carried out in other natural sciences. It has also provided natural scientists with first hand experience of carrying out social science research. The impact of the interaction lies in the future.

With regards to further research, this scoping study has identified a need for a more detailed study focusing on key aspects. These are

- The roles of a wide range of stakeholders (farmers, rural businesses, other land-users, recreational users, lobby groups, different types of researchers, funders, the media and policy makers) in shaping science and knowledge production.
- A more critical perspective on what 'inter-disciplinarity' means in practice (both within projects and in the interpretation of knowledge from different disciplines, scales and types of knowledge producers).
- A more detailed consideration of the role of trust and power among different members of research teams / beneficiaries / research users / funders and policy makers
- A better understanding of the tensions between the need to develop 'relevant science' for practical use by farmers, businesses and land users, and academically rigorous 'high science' for academic publication
- Detailed studies of specific interesting cases that could not be addressed in this scoping project such as GM trials, Foot and Mouth Disease research, research shaping the Water Frame Directive and research on agri-environment measures.

Appendix I.

Methodology

1. Literature review

A review of the literature provided the material for a conceptual framework to be examined and tested through the project, and the development of an interview checklist. The review examined literature from agricultural research methodologies, small business strategic management and innovation, and the sociology of science.

2. Selection of case studies

In total 10 cases of farming enterprises working with scientists were examined. These were selected purposely from existing and completed research projects, and ensured that there are a range of different approaches to interaction and different degrees of collaboration/ participation. Within each case study, semi-structured interviews took place with a minimum of four individuals having differing roles, including farmers, advisors, researchers and funders.

3. Data collection

Data was gathered using semi structured interviews and observations. The topic guide for the interviews was used to collect background information on the individual being interviewed and their organisation (see next page). Detailed probing was used to explore how they are going about their research and learning, their interaction with other stakeholders, and external factors that have shaped this. Particular attention was given to exploring what happened at 'critical incidents' such as meetings to discuss the research objectives or results. Observations of people's reactions to questions are also important in terms of documenting information that might be tacit knowledge or gut reactions to particular issues (Ambrosini and Bowman, 2001). Interviews were carried out by natural, biological and social scientists, with training provided to those who had not had experience of interviewing before.

4. Data analysis

The comparison of differences between cases studies of the same type and between different types of groups allowed conclusions to be drawn (Yin 2003). Drawing on the grounded theory approach (Strauss and Corbin 1998), the microscopic details of the data was examined. This involved careful analysis of comments and reactions of respondents such as the use of laughter and non-verbal responses to particular questions. While there is potential bias from the small sample and the role of the interviewers/data analysers, validity and accuracy was based on ensuring a range of techniques were used (interviewing, observations, informal discussions), combined with a sampling of cases allowing cross case comparison and the cross checking of issues from multiple sources ('triangulation').

Researcher Interview Questions

1. How did the project come about?

Who were the instigators.

How did the team change over the project? Why

How did you get involved?

What experience of interdisciplinary research/farmer involvement did you have before?

How were others chosen to join the team? What history of working together?

How did you know the others were going to co-operate and do as expected?

2. How did you identify the research question?

Who were the target audience?

Who funded the research? Did the funder demand an interdisciplinary approach?

What different academic approaches were there?

How were different views accommodated?

What difficulties did you face in setting research priorities?

Who had more influence at this stage in the process?

How were farmers and users involved in setting the research goals?

3. How did you develop the methodology to be used.

How did you divide up the research? How were methods decided for each part?

How did you balance the need to be interdisciplinary with the need for rigorous research?

What are the challenges associated with including farmers in research?

What are the challenges of doing systems research?

What indicators or measurements were taken?

What scales were you looking at? how were small scale results applied to a wider scale?

What statistical analysis was included in the project? Who did it? When and who decided?

What qualitative data was collected, and how was it analysed?

Who was involved in evaluating the results, analysing the data, and writing it up?

4. How did the project run?

In which ways did you work together?

In what way were farmers and other businesses involved in the research?

What difficulties did you face understanding others? How did you get over this?

Did you feel there was competition among team members to take the lead within your research area?

To what extent did others in the team understand the key issues within your discipline?

Where there any disagreements? What happened?

Did any team members not do as expected? What happened

5. What outputs were required by the project, your institutions and for your career?.

How were the results disseminated?

How did your research influence farmers/land users or policy makers?

Who was involved in writing?

Where were results published? Was it easy to decide where to submit papers? Was it hard to get papers accepted?

6. What happened after the project?

How did the project affect the way you worked on subsequent projects? How did it affect others?

Were some collaborations maintained?

7. What have you learnt from the participating in this project.

What are the constraints on interdisciplinary research?

How has funding encouraged or discouraged the research?

How has your institution encouraged or discouraged the research?

How does the RAE influence research approaches?

How has your involvement in interdisciplinary research helped or hindered your career?

Interview Checklists for Farmers, agri-businesses, advisors

1. How did you originally come to be involved in the project?

Had you worked with them before?
Who approached who?
Who else was involved in it?
In what way were advisors involved?
At what stage of then project did you get involved?
What was your involvement?
How did you know you were going to benefit?

2. Who decided the topic?

How relevant is this to your needs?
Who decided what was being looked?

3. Who monitored and took measurements? Describe.

4. Did you monitor the experiment for your own interest? Do you try other things yourself?

How did you know if it was working or not?
What factors did you consider?
What measurements did you take and how?
What did you compare it to?
How did you know that it was caused by the changes you made (how can you attribute cause and effect)?

5. What did you get out of it?

When did you see any results?
Are you still using the results in practice? If not, why not?
Have you shared the results with anyone else? Who? Why?

6. How has it changed your perception of what scientific research can deliver?

What have you learnt about working with scientists?
What did the scientists get out of it?
Did the scientists listen to your views? In what way?
Has it encouraged you to try new things yourself?
Would you be involved in other research projects in the future?
How can research be made more relevant to your business?

7. What other links or contact have you had with scientific researchers in the past?

In your view, what are the different types of scientists?

Appendix II

Bibliography

- Ambrosini, V and Bowman, C (2001) 'Tacit knowledge: Some suggestions for operationalization' in *Journal of Management Studies* 38 (6)
- Anderson, J.R. & Hardaker, J.B. (1992) Efficacy and Efficiency in Agricultural-Research - a Systems View. *Agricultural Systems*, 40, 105-123.
- Archer, J., Jamieson, B.G. and Wingfield, N. (2004) Evaluation of the Organisation and Management of the GMHT Farm Scale Evaluations (FSEs) pp. 55. Brian Jamieson & Associates.
- Ashby, J.A. (1986) Methodology for the Participation of Small Farmers in the Design of on-Farm Trials *Agricultural Administration* 22 1-19
- BASF (1994) 'Appropriate fungicide dose rates for cereals' in *The Agronomist*, The BASF magazine for the progressive farmer No 2
- Baur, H and Kradi, C (2001) 'Integrating participatory Research methods in a public agricultural research organisation: A partially successful experience in Morocco' *Agricultural Research and Extension Network Paper* No 109
- Bawden, R.J. (1991) Systems Thinking and Practice in Agriculture. *Journal of Dairy Science*, 74, (7) 2362-2373.
- Bawden, R.J. (1992) Systems Approaches to Agricultural-Development - the Hawkesbury Experience. *Agricultural Systems*, 40, 153-176.
- Becket, J V (1990) *The Agricultural Revolution* Basil Blackwell, Oxford
- Bentley, J W (1992) 'Promoting farmers experiments in non-chemical pest control' Paper prepared for IIED/IDS Beyond Farmer First: Rural Peoples' Knowledge, Agricultural Research and Extension Practice Workshop, Institute of Development Studies, University of Sussex, 27-29 October 1992 (Shortened version in Scoones, I and Thompson, J (1994))
- Berkes, F. and Folke, C. . (1998) *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press. 459 pp.
- Bessant J., S. Caffyn, J. Gilbert, R. Harding, and S. Webb (1994) 'Rediscovering Continuous Improvement' *Technovation* 14(1), 17-29.
- Biggs, S (1990) 'A multiple source of innovation model of agricultural research and technology promotion. *World Development* 18 (11), 1481-1499
- Brewer, G.D. (1999a) "The challenges of interdisciplinarity." *Policy Sciences* Vol. 32, p327-339.
- Brewer, G.D. (1999b) "Reflections" *Policy Sciences* Vol. 32, p421-429.
- Chambers, R (1983) *Rural Development; Putting the Last First* Longmans, Harlow, UK
- Chambers, R (1997) *Whose reality counts? Putting the first last*, Intermediate Technology Publications, London
- Chambers, R., A. Pacey and L.I. Thrupp (1989) *Farmer First: Farmer innovation and agricultural research*. London, IT.
- Checkland, P. (1999), *Systems Thinking, Systems Practice* Chichester: John Wiley & Sons, Ltd.

- Chell E. (1998) 'Critical Incident Technique', in Symon G. and Cassell C. (eds) 'Qualitative Methods and Analysis in Organisational Research-a Practical Guide', Chapter 4, pp51-72, London: Sage
- Cobb, D., Feber, R., Hopkins, A., Stockdale, L., O'Riordan, T., Clements, B., Firbank, L., Goulding, K., Jarvis, S. & Macdonald, D. (1999) Integrating the environmental and economic consequences of converting to organic agriculture: evidence from a case study. *Land Use Policy*, **16**, 207-221.
- Cohen, W. M. and D. A. Levinthal (1990) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, Vol. 35, 128-152.
- Connell, J (1990) 'Farmers experiment with a new crop' *ILEIA Newsletter* 6(1)
- Conway, G.R. (1985) Agroecosystem Analysis. *Agricultural Administration*, 20, 31-55.
- Conway, G.R. (1987) The Properties of Agroecosystems. *Agricultural Systems*, 24, 95-117.
- Danbom, D B (1986) 'The agricultural experimentation station and professionalisation; scientists' goals for agriculture' in *Agricultural History*, 60 (2)
- Dankbaar, B. (1994) 'Technology management in technology-contingent SMEs', *International Journal of Technology Management*, 15(1/2), 70-81.
- Delate, K. (2002) Using an agroecological approach to farming systems research *Horttechnology* 12 345-354
- Drinkwater, L.E. (2002) Cropping systems research: Reconsidering agricultural experimental approaches *Horttechnology* 12 355-361
- Dyke, G V (1974) *Comparative Experiments with Field Crops* London, Butterworths
- Farrington, J., and Martin, A. (1988) 'Farmer participatory research; a review of concepts and practices'. *Agricultural Research and Extension Network Discussion Paper 19* London; ODI
- Flora, C.B. (1992) "Building sustainable agriculture – A new application of farming systems research and extension." *Journal of Sustainable Agriculture*, Vol 2, Iss. 3 pp 37-49.
- Galmiche-Tejeda, A. (2004) "Who is interdisciplinary? Two views, two goals, professionals and farmers." *Interdisciplinary Science Reviews* Vol 29, No 1, p.77-95.
- Gambetta, D. (1988), "Can we trust trust?," in *Trust: Making and Breaking Cooperative Relations*, D. Gambetta, ed. Oxford: Blackwell, 213-37.
- Gauch, H.G. (1992) Statistical analysis of regional yield trials : AMMI analysis of factorial designs, Elsevier, Amsterdam.
- Gibbon, D. & Schultz, M. (1992) Farming Systems Research in Remote Areas in Nepal - the Need for a New Approach to on-Farm Research and Extension. *Experimental Agriculture*, 28, 203-209.
- Gibbon, D. (2002) Systems thinking, interdisciplinarity and farmer participation: essential ingredients in working for more sustainable organic farming systems In *Proceedings of the UK Organic Research 2002 Conference* 26-28th March 2002, Aberystwyth, Wales.

- Gibbon, D. and Jiggins, J. (2000) "Interdisciplinarity, internationalisation and learning systems for agricultural education in transition." Presented to *From production agricultural to rural development*, 5th European conference on higher agricultural education. Seal-Hayne Faculty, University of Plymouth, 9-13 September, 2000.
- Grabher, G. (1992) *The Embedded Firm - on the socio economics of industrial networks*, London: Routledge.
- Harris, F (2000) Workbook on participatory research on IITA project
- Harris, G.H., Hesterman, O.B., Paul, E.A., Peters, S.E. and Janke, R.R. (1994) Fate of legume and fertilizer nitrogen-15 in a long-term cropping systems experiment *Agronomy Journal* 86 910-915
- Hassink, R. (1996) 'Technology Transfer Agencies and Regional Economic Development' *European Planning Studies*, 4(2), 167-184.
- Haverkort, B (1991) 'Farmers' Experiments and Participatory Technology Development' in B Haverkort, J Van der Kamp and A Walters-Bayer (eds) *Joining farmers Experiments: Experiences in Participatory Technology Development* IT publications, London
- Hildebrand, P.E. & Russell, J.T. (1996) Adaptability analysis : a method for the design, analysis, and interpretation of on-farm research-extension, Iowa State University Press.
- Hodgson, G. M. (1988), *Economics and Institutions: A Manifesto for a Modern Institutional Economics*. Cambridge: Polity Press.
- Hoffman, K., M. Parejo, J. Bessant and L. Perren (1998) 'Small firms, R&D, technology and innovation in the UK: a literature review', *Technovation*, 18(1), 39-55.
- Ison, R (2002) Developments in theory and practice of the concept of agroecosystems, unpublished paper from Open University, Centre for Complexity and Change.
- Kloppenbergh, J (1991) 'Social theory and the de/reconstruction of agricultural science: local knowledge for an alternative agriculture' in *Rural Sociology* 56 (4)
- Knorr Cetina, K. (1992). The couch, the cathedral, and the laboratory: On the relationship between experiment and laboratory in science. In A. Pickering (Ed.), *Science as Practice and Culture*. Chicago: University of Chicago Press.
- Knorr-Cetina, K D (1981) *The Manufacture of Knowledge: An Essay on the constructivist and contextual Nature of Science* Pergamon Press, Oxford
- Latour, B (1987) *Science in action: how to follow scientist and engineers through society*. Cambridge M.A. Harvard University Press
- Latour, B and Woolgar, S (1979) *Laboratory Life: the construction of scientific facts*, Los Angeles, CA, Sage
- Lau, L. and Pasquini, M.W. (2004) " Meeting grounds: perceiving and defining interdisciplinarity across the arts, social sciences and sciences." *Interdisciplinary Science Reviews* Vol 29, No 1, p.49-64.
- Lawrence, J.R. and Depres, C. (2004) "Introduction. Futures of transdisciplinarity." *Futures* Vol. 36, p 397-405

- Leeuwis, C (2000) 'Reconceptualizing participation for sustainable rural development: towards a negotiation approach', *Development and Change*, 31 (5), 931-959
- Levi, M. (1996) "Social and unsocial capital: a review essay of Robert Putnam's *Making Democracy Work*," *Politics and Society* 24,1, 45-55.
- Lyon, F (2005) 'Managing co-operation - trust and power in Ghanaian associations' *Organization Studies* November 2005
- Lyon, F (2000) 'Trust, networks and norms: The creation of social capital in agricultural economies in Ghana', *World Development* 28, 4 pp.663-682
- Lyon, F. (1996) 'How farmers research and learn: The case of arable farmers in East Anglia, UK' in *Journal of Agriculture and Human Values* 13 (4) pp39-47.
- Martin, A and Sherrington, J (1997) 'Participatory research Methods – Implementation, effectiveness and institutional context' in *Agricultural Systems* 55 (2) 195-216
- Martin, A. and Sherrington, J. (1997) Participatory research methods - Implementation, effectiveness and institutional context *Agricultural Systems* 55 195-216
- Mendras, J (1970) *The vanishing peasant: innovation and change in French agriculture* Cambridge
- Misztal, B. A. (1996), *Trust*. Cambridge: Polity Press.
- Molnar, J J, Duffy, P A, Cummins, K A and Van Santen, E (1992) 'Agricultural science and agricultural counterculture: paradigms in search of a future' in *Rural Sociology* (57)1
- Mueller, J.P., Barbercheck, M.E., Bell, M., Brownie, C., Creamer, N.G., Hitt, A., Hu, S., King, L., Linker, H.M., Louws, F.J., Marlow, S., Marra, M., Raczkowski, C.W., Susko, D.J. and Waggoner, M.G. (2002) Development and implementation of a long-term agricultural systems study: Challenges and opportunities *Horttechnology* 12 362-368
- Nelson, R. and S. Winter (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.
- Newell, S and Swan, J (2000) Trust and inter-organizational networking, *Human Relations* 53 (10) 1287-1328
- Nissani, M. (1997) "Ten cheers for interdisciplinarity: The case for interdisciplinary knowledge and research." *The Social Science Journal*. Vol 43 No. 2 p201-206
- Nonaka, I (1991) 'The knowledge creating company' in *Harvard Business Review*, 69 (6)
- Norman, D W et al (1998) 'Farmers attitudes concerning on-farm research: Kansas Survey Results' in *Journal of Natural Resources and Life Science Education* 27
- Oakey, R. P. and T. White (1993) 'Business information and regional economic development: some conceptual observations', *Technovation*, 13(3), 147-159.
- Odum, E P (1989) 'Input management of production systems' *Science* 243 (13 January) 177-82

- Okali, C., J. Sumberg and J. Farrington (1994) *Farmer Participatory Research: Rhetoric and Reality* London: IT Publications.
- Platteau, J.-P (1994) "Behind the market stage where real societies exist - Part II The role of moral norms," *Journal of Development Studies* 30,4, 753-817.
- Polanyi, K (1966) *The Tacit Dimension* New York, Doubleday.
- Porter, M E (1990) *Competitive Advantage of Nations*
- Pretty, J (2001) *The Living Land*, Earthscan Publications Limited, London.
- Pretty, J (1991) 'Farmers' Extension Practice and Technology Adaption: Agricultural Revolution in 17th-19th Century Britain' in *Agriculture and Human Values* 8 (1-2)
- Pretty, J (1995) 'Participatory Learning for Sustainable Agriculture' in *World Development* 23 (8)
- Pretty, J and Chambers, R (1994) 'Towards a learning paradigm: new professionalism and institutions for a sustainable agriculture' in
- Putnam, R. (1993) *Making Democracy Work: Civil Traditions in Modern Italy*. Princeton: Princeton Univ Press.
- Reijntjes, C , B Haverkort and A Waters-Bayer (1992) *Farming for the future: An introduction to Low-External Input Sustainable Agriculture* London, Macmillan
- Richards, P (1989) 'Agriculture as performance' in Chambers, R., A. Pacey and L.I. Thrupp *Farmer First: Farmer innovation and agricultural research*. London, IT.
- Richards, P. (1985) *Indigenous Agricultural Revolution; ecology and food production in West Africa*. Hutchinson, London and Westview Press, Boulder
- Richards, P. (1986) *Coping with Hunger; hazard and experiment in an African Rice farming system* Allen and Unwin, London
- Richards, P. (1994) ' Rural Development and local knowledge; the case of rice in Sierra Leone' in Scoones, I and Thompson, J (1994) *Beyond farmer First: rural people's knowledge, agricultural research and extension practice*. IT Publications)
- Riley, J. (1996) Design considerations for participatory on-farm research In *Kakamega Workshop, Kenya, March 18 to 22, 1996*.
- Riley, J. and Alexander, C.J. (1997) Statistical literature for participatory on-farm research *Experimental Agriculture* 33 73-82
- Robbinson J et al, (1997) 'A view of science, agricultural science and farming systems research in these post modern times' www.apsru.gov.au
- Roep, D and de Bruin, R (1994) 'Regional marginalisation, styles of farming and technology development' in van der Ploeg, J D and Long, A *Born from within: practice and perspectives of endogenous rural development* Van Gorcum, Netherlands
- Rogers, E (1983) *The diffusion of innovations*. New York: Free Press.
- Rothwell, R. (1991) 'External networking and innovation in small and medium-sized enterprises' *Technovation*, 11(2), 93-112.
- Sands, D.M. (1986) Farming Systems Research - Clarification of Terms and Concepts. *Experimental Agriculture*, 22, 87-104.

- Schon, D (1983) *The Reflexive Practitioner. How professionals think in action*, Basic Books, New York
- Schroder, P., Huber, B., Olazabal, U., Kammerer, A. and Munch, J.C. (2002) Land use and sustainability: FAM Research Network on Agroecosystems *Geoderma* 105 155-166
- Schumpeter, J (1934) *The Theory of Economic Development*. Oxford, Oxford University Press
- Scoones, I (1998) Sustainable rural livelihoods: A framework for analysis' Working paper 72. Brighton, Institute of Development Studies
- Scoones, I and Thompson, J (Eds.) (1994) *Beyond farmer First: rural people's knowledge, agricultural research and extension practice*. IT Publications
- Scott, A., Skea, J., Robinson, J. and Shove, E. (1999). Designing 'interactive' environmental research for wider social relevance. Brighton, Economic and Social Research Council Global Environmental Change Programme: 16. Special Briefing No. 4.
- Scott, J. C. (1976), *The Moral Economy of the Peasant*. New Haven: Yale University Press.
- Seaton, R. A. F. and M. Cordey-Hayes (1993) The development and application of interactive models of industrial technology transfer, *Technovation*, 13(1), 45-53.
- Sepanem, L and Padel, S (1999) How to apply a holistic interdisciplinary approach to development/extension in Zanoli and Krell, *First SREN Workshop on Research Methodologies in Organic Farming*. Rome, FAO
- Sillitoe, P. (2004) Interdisciplinary experiences: working with indigenous knowledge in development. *Interdisciplinary Science Reviews* Vol 29, No 1, p.6-23.
- Smallbone D, North D and Vickers I (2003) The role and characteristics of SMEs, in C Nauwelaers et al (eds.) *Regional Innovation Policies for SMEs*, Edward Elgar.
- Sperling, L., Loevinsohn, M. and Ntabomvura, B (1993) Rethinking the Farmer's Role in Plant Breeding: Local Bean Experts and On-Station Selection in Rwanda, *Experimental Agriculture*, 29 (4) 509-519
- Stolzenbach, A (1992) Learning by improvisation: the logic of farmers experimentation in Mali, Paper prepared for IIED/IDS Beyond Farmer First: Rural Peoples' Knowledge, Agricultural Research and Extension Practice Workshop, Institute of Development Studies, University of Sussex, 27-29 October 1992
- Strachan, R. & Holmes-Ling, P. (2003) Restoring Water Voles and other Biodiversity to the Wider Countryside: A report on the Chichester Coastal Plain Sustainable Farming Partnership, pp. 83. Wildlife Conservation Research Unit, University of Oxford, Oxford.
- Strauss, A. L. and J. Corbin (1998), *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. California: Sage Publications.
- Sumberg, J and Okali, C (1997) *Farmers' Experiments: Characteristics and Implications*

- Sumberg, J., Okali, C and Reece, D (2002) 'Agricultural research in the face of diversity, local knowledge and the participation imperative: theoretical considerations', Unpublished Overseas Development Group, University of East Anglia.
- Suppe, F (1987) 'The limited applicability of agricultural research' in *Agriculture and Human Values* 4 (4)
- Thirsk, J (1987) *England's Agricultural Regions and Agrarian History, 1500-1700. Studies in Economic and Social History*. Macmillan Educational, Basingstoke
- Thompson-Klein, J. (2004) "Prospects for transdisciplinarity" *Futures* Vol. 36, p 515-526
- van de Ploeg, J D (1990) *Labour, markets and agricultural production* Boulder Colorado, Westview Press
- van der Bleik, J and van Veldhuisen, (1993) 'Developing tools together: Report of a study on the role of participation in the development of tools, equipment and techniques in appropriate technology programmes' Eschborn/Leusden, GATE/ETC
- van der Ploeg, J D and Long, A (1994) *Born from within: practice and perspectives of endogenous rural development* Van Gorcum, Netherlands
- van Dusseldorp, D and Box, L (1993) 'Local and scientific knowledge; developing a dialogue' in de Boef, W, Amanor, K and Wellard, K with Bebbington, A, *Cultivating Knowledge; Genetic Diversity, Farmer Experimentation and Crop Research* IT Publications, London
- Waibel, H. and Benden, D (1990) 'Farmers as members of research teams in experiment stations' Paper presented at the workshop on Peasant Household System, Partners in the process of development, DSE, Feldafing, West Germany, April, 1990.
- Whatmore, S. 2005. Presentation to "Re-tying the knot" at the annual RGS-IBG conference, Royal Geographical Society, Thursday Sept 1, 2005.
- Wilson, D (2002) 'Farmers and Organic Research', Proceedings of the UK Organic Research 2002 Conference, Aberystwyth.
- Yin, Robert (2003) *Case study research design and methods*. London: Sage.

Appendix III

Details of case studies

Short Title Home farm Organic Farming Study

Duration: 1993-1996

Lead Organisation: University of East Anglia

Funder: Economic and Social Research Council (ESRC), the Biotechnology and Biological Sciences Research Council (BBSRC) and the Natural Environment Research Council (NERC)

Project Summary: This project was funded jointly by the three UK research councils (BBSRC, ESRC & NERC) and aimed to compare organic and conventional farming by examining agronomic, economic and ecological factors. This was done by: establishing the efficiency of nutrient cycles; assessing vegetation changes in field margins and grassland; examining the impact of different farming systems on certain fauna (e.g. butterflies and small mammals); and carrying out a full socio economic audit of a developing organic farm. The project concluded that although nutrient cycles were relatively efficient and there were biodiversity and social gains in farming organically, the cost of transition to organic agriculture was not covered by the current conversion support payments (Cobb *et al.*, 1999).

Project Instigation:

- The project was instigated by an influential public figure. A preliminary meeting was held at Home Farm, Tetbury involving the landowner, the project leader, the heads of the three research councils (BBSRC, ESRC, NERC) and the farm manager.
- The multidisciplinary nature of the project was a new concept which meant that there were no formal structures to cope with it.
- A steering committee consisting of representatives of the research councils, Home Farm's manager, members of partner organisations from the organic movement developed general research questions.

Involvement of farmers/other businesses:

- The manager of Home Farm was involved from the outset. Other neighbouring farms were also involved.
- The farm manager did not influence the academic side of the project but did make points on the practicalities of the project.

Methods used:

- Data was collected on nutrient inputs, transfers and outputs.
- Vegetation in field margins and cropped area was assessed.
- The impacts of organic farming on several species of fauna (including butterflies and woodmice) were assessed.
- The social scientists involved did not set the methodology for the natural scientists, but tried to make linkages between the different aspects of the project.

Analysis:

- Nutrient budgets were calculated.
- Biodiversity data was analysed comparing habitats and organic versus non-organic systems.

- The results were based on the impact per hectare rather than per tonne of wheat produced.

How the project ran:

- This was the first attempt to get the three research councils to work together.
- Some of the scientists were not used to being involved with a working farm, with its associated practical issues.
- The different scientists often had differing perspectives and different priorities.
- It was felt that there was more collaboration between researchers at ground level than among the scientists co-ordinating the project.
- Despite the multidisciplinary nature of the project, some scientists perceived that others remained tied to their disciplines.

Outputs:

- Peer reviewed papers were written, both about individual aspects of the project and integrating environmental and economic data.
- A leaflet was written to give to visitors to Home Farm.

After the project:

- The farm manager continues to monitor some fields and still works with researchers on some projects if he feels that they are worthwhile.
- Some of the researchers kept in touch on a social level for a while after the project ended.
- Most researchers returned to working within their own discipline.
- Some further funding was sought but failed because it required all three research councils to approve the idea which was very challenging.

Other issues:

- It was thought that there are constraints to interdisciplinary research as a result of employment structures and the RAE. The RAE promotes the publication of work in high quality journals which are monodisciplinary and so interdisciplinary papers are not as highly valued.
- One researcher said that assembling an interdisciplinary research team takes time and so this sort of project should be longer than the usual three years. The researcher thought that interdisciplinary team building should be seen as an output in itself.

Case 2. Project Title: Chichester Coastal Plain Sustainable Farming Partnership

Short Title (For the purposes of this report): WildCRU Chichester Coastal Plain Sustainable Farming Partnership

Duration: ?

Lead Organisation: Wildlife Conservation Research Unit (WildCRU), University of Oxford

Funder: The Environment Agency, West Sussex County Council, various wildlife and charitable trusts.

Project Summary: The main aim of this project was to establish a demonstration area of the best practice for sustainable farming and biodiversity enhancement, where land managers and practitioners could experience sympathetic management first hand. The project highlighted the problem of diffuse pollution, the benefits of buffering watercourses and demonstrated actions for enhancing biodiversity. It also examined the best practice and restoration options that could enhance habitats on farmland and improve the connectivity of the floodplain with its backwaters, ponds, wet grassland, marshes, reedbeds and ditch network. The effectiveness of these various options were tested through a series of comparative experiments designed to measure changes in habitat and abundance of key biodiversity indicator species (such as the water vole) (Strachan & Holmes-Ling, 2003).

Project Instigation:

- Members of WildCRU and a FWAG had ideas and decided to work together.
- The researchers involved West Sussex County Council, the Environment Agency and wildlife and charitable trusts to gain funding.
- The FWAG advisor recruited farmers in the area.
- Chichester coastal plain was outside a targeted area so the researchers started with a 'clean slate'.
- Different partners had different objectives.

Involvement of farmers/other businesses:

- Farmers in the Chichester coastal plain were contacted and asked if they would be involved. About 80-90% of the land area was included in the project (43 holdings). A few farmers declined to be involved.
- Farmers decided on what stewardship options they would put in place after being given advice. Farmers were sometimes concerned about how much implementing treatments would cost.
- It was felt that some farmers were very enthusiastic and got involved whereas others just tolerated the presence of the researchers.
- Farm walks were hosted by some of the farmers.
- Farmers benefited from having good publicity in the local press.

Methods used:

- Visits were made to farmers by researchers and advisors and whole farm plans were developed and stewardship schemes entered into.
- The FWAG advisor gave advice about stewardship options and ditch management possibilities.
- The lead researcher designed experiments looking at transects within the area using paired treatments. Biodiversity surveys were carried out, looking at birds and species such as water voles and brown hares. The scale that the experiment was at differed with the species being studied.

- Water voles were encouraged by enhancing their habitat (ditch management), population reinforcement and mink removal.
- In some cases, derogations had to be sought in order to be able to cut the vegetation on the sides of the ditches as desired.

Analysis:

- Data analysis was carried out by statisticians and GIS people at the researcher's institution.
- Analysis methods included descriptive analysis, tests on frequency and abundance (comparative and associative analysis) and generalised linear models.

How the project ran:

- It was important for the researcher and advisor to attend farms together for the initial meetings.
- It was felt that the project ran well because the researchers got on well and the fact that they had a good relationship with the funders.
- There were some mistakes in the management on a few farms. However, there were many replicates and the data set was large so this did not affect the project.

Outputs:

- Information packs containing practical information were developed as well as 'How to..' leaflets.
- It was important for those involved that the final report was a document that farmers could and would want to read.
- The meetings at the end of the project were well attended, especially by local people. Farmers were pleased to be able to show the community that they were benefiting the environment and biodiversity.

After the project:

- Similar work is being carried out by WildCRU on a larger (landscape) scale.

Other issues:

- It was thought that research should have a wider applicability and not be too species or location specific.

Case 3. Project Title: Sustainable Arable Farming For an Improved Environment – SAFFIE – enhancing biodiversity

Short Title (For the purposes of this report): SAFFIE

Duration: 5 Years (Jan 2002 – ongoing)

Lead Organisation: ADAS

Funder: Sustainable Arable LINK Programme. Government sponsors: Defra, SEERAD and English Nature. Industrial partners include: British Potato Council, Crop Protection Association (as part of the voluntary initiative), RSPB, Safeway stores plc, Sainsbury's supermarkets Ltd, Syngenta, HGCA and the National Trust.

Project Summary: The objective of this project is 'to enhance farmland biodiversity and develop more sustainable farming by integrating novel management approaches in the crop and uncropped margins'. The project is split into 3 main experiments. Experiment 1 is concerned with the management of the crop. It is looking at how crop architecture affects birds and how crop protection inputs can be used to maximise biodiversity. Experiment 2 is studying how different grass seed mixtures sown in the margin and managed under three options affect biodiversity. The third experiment assesses the integrated effects of using four of the best crop and margin management strategies in a factorial design on bird populations, biodiversity and agronomy. A cost-benefit analysis will be carried out on the best practices. The project is ongoing.

Project Instigation:

- The project came from a LINK call to look at biodiversity. Three consortiums put in three different proposals and were told to work together.
- Meetings to decide protocols involved negotiation and compromises had to be made.
- As a result of the amalgamation, some of the organisations involved in the original proposals dropped out.
- There has been some team changes through the project.

Involvement of farmers/other businesses:

- The project management committee is chaired by a farmer and there are farmers on the committee. They comment on the practicalities of ideas.
- The experiments are carried out on farmers' fields.. It had been more difficult to engage with sufficient farmers than expected. There have been some difficulties in farmers management of the sites eg delayed drilling due to poor weather.
- Farmer meetings have been held.

Methods used:

- Field experiments on 26 commercial farms around the country.
- There are 3 experiments. Experiment 1 is looking at crop management, experiment 2 is looking at margin management and experiment 3 follows on to determine the best combination of crop and margin management.
- As well as ecological data, economic data is also collected for a cost-benefit analysis.

Analysis:

- A lot of farms are required to pick up effects when data are analysed.

- Statisticians weren't involved at the beginning of the project but were brought in later. It was thought that it would have been helpful for statisticians to be involved at the design stage.
- Statisticians have also helped to set up a common database.
- Each organisation does their own analysis.
- There are issues of scale since different species work at different scales.

How the project ran:

- Most researchers had worked on inter-disciplinary projects before.
- Approaches have evolved as the project has gone on.
- There are a lot of researchers involved so a lot of meetings are necessary.
- Different organisations have their own preferred methods.
- Organisations tend to conduct their own part of the research. Each organisation has their own milestones. However, The Game Conservancy Trust work with CSL to collect the same data from different parts of the country.
- IT was not costed in.
- It was thought that there was insufficient time between the first part (experiments 1 and 2) and experiment 3.
- Researchers from different organisations have different drivers.
- It was suggested that the project should have been extended to allow more time for analysis and writing.

Outputs:

- Peer-reviewed papers.
- Practical advice for land management.
- Presence at agricultural events and in the agricultural press.

After the project:

- The project is ongoing. However, researchers said that they would work with others in the consortium again.

Case 4. Project Title: Evaluation of the pilot Entry Level Agri-environment scheme

Short Title (For the purposes of this report): Entry level scheme pilot project

Duration: 01/05/03 – 29/02/04

Lead Organisation: Central Science Laboratory

Funder: Defra

Project Summary: This project was a pilot of a new agri-environmental scheme which aimed to encourage farmers to deliver environmental management in the areas of biodiversity, landscape, the historic environment and diffuse pollution. The Entry Level Scheme (ELS) was tested in four areas of England, representing four different farming types (grassland, arable, upland, mixed) and was open to all farmers in those areas. Participating farmers developed a plan of the management they would carry out, made up of a number of options, each worth a certain number of points. Research was then conducted into the likely environmental impact of the scheme and information was gathered on the uptake, acceptability and administration of the scheme. It was concluded that the pilot was a success and the ELS had a high level of support and had the potential to deliver substantial environmental benefits.

Project Instigation:

- CSL bid for a tender. Defra already knew what they needed from the project. The project was atypical because Defra was very hands-on.
- A steering group was also involved in writing the specification. The steering group included organisations like English Nature, the Environment Agency, Countryside Agency and NGO's as well as the national parks authority, NFU and CLA.
- The researchers had worked together on other projects.
- It took a long time to develop the methodology. The questions were clarified with Defra. The measurements taken were dictated by the ELS options.

Involvement of farmers/other businesses:

- Farmers in four specific pilot areas, chosen to represent four different farming types (grassland, arable, upland, mixed), were asked if they would participate. The size of farm differed considerably.
- Willing farmers tried out the Entry Level Scheme. Biodiversity measurements were carried out on a selection of the participating farmers.
- Farmers in the pilot areas that did and did not undertake the scheme were surveyed.
- One farmer helped to promote the project by giving talks and farm walks to farmers, talking to the media and being at the official launch.
- Advisors were used in each of the pilot areas to run workshops for farmers to enter the pilot scheme.

Methods used:

- Questionnaires were used. Researchers had used them before and knew how to analyse them. However, they ended up being long.
- Defra wanted qualitative data to be collected.
- Surveys of biodiversity were carried out. CSL liaised with other organisations in the steering group, particularly to develop a common scoring system. However this system was not used much in the final report
- An expert assessment approach was used which looked at the value of the different prescriptions. Experts included people from Defra, RDS and members of the steering group.

Analysis:

- The data was analysed by a team at CSL.
- Environmental outcomes were modelled and results from pilot areas were scaled up to a national level.

How the project ran:

- The project went well and the researchers found it interesting but they were under tight deadlines.
- There was a danger that only a certain type of farmer would be willing to participate in the scheme.
- Good communication was important.
- The farmer interviewed thought that the Defra contact was very helpful.
- There was also a good exchange of ideas between the farmers involved.

Outputs:

- The project influenced policy. It brought up lots of issues about the ELS, especially the interpretation of the options, which could then be ironed out.

After the project:

- The researchers are working together on other projects.
- One researcher now uses the information he has gained from this project to help other farmers.

Other issues:

- It was felt by one researcher that although it would be nice to publish more papers, they do not have time as new projects are needed to fund staffing.

Case 5. Project Title: Nickersons, Brown and CoThe Buster Club

Short Title (For the purposes of this report):

Duration: Ongoing

Lead Organisation: Nickersons

Funder: Nickersons

Project Summary:

Nickersons is a plant breeding company, with a specific interest in wheat breeding. As part of their work, they have worked with Brown and Co (farm consultants) to involve a group of farmers, the Buster Club, who give them feedback on the criteria farmers are looking for and share their opinions on different varieties being developed. The group meet informally several times a year, with farm walks, visits to trial sites and discussions in the pub. Farmers can also try varieties early and be involved in seed growing of new varieties. The group is also involved in visits to buyers and users of wheat.

Project Instigation:

- After a visit to Nickerson's, farmers suggested setting up a group. This is known as the Buster Club.
- Brown and Co (farm consultants) organise meetings, invites farmers to join and has an administrative role.

Involvement of farmers/other businesses:

- The group is limited to about 12, although there is a waiting list.
- Farmers go on visits to breeders and other auxiliary industry companies.
- Farmers are given varieties to try and bulk up so that they can be released to the market earlier.
- Farmers give feedback on the varieties.

Methods used:

- Varieties are tested by farmers. This benefits the farmers and also the breeders as they can see how the varieties work on different land and in different environments.
- The breeders try to get farmers to adjust their agronomy to different varieties.
- Breeders talk to farmers about what they want out of varieties and what the problems are. No formal data collection on this is carried out, but the breeders take the information into account when developing new varieties.

Analysis:

- No statistical analysis is carried out on variety performance, but trends are examined.

How the project ran:

- Farmers get on well with the breeders and will often phone them up for advice or to ask questions.
- The breeders at Nickerson's have the respect of farmers because of their honesty about their varieties.

Outputs: Varieties are fast-tracked and released quicker than usual.

After the project: The project is ongoing.

Case 6. Project Title: Integrated control of wheat blossom midge: Variety choice, use of pheromone traps and treatment thresholds.

Short Title (For the purposes of this report): Wheat Blossom Midge project

Duration: 3 years, 5 months (October 2001- March 2005)

Lead Organisation: ADAS

Funder: Part of the Sustainable Arable LINK programme. Funding came from Defra and HGCA plus in-kind contributions from seed and chemical companies and a midge trap manufacturer.

Project Summary: The objective of this project was to develop a system of integrated control of orange wheat blossom midge (OWBM). This was done by determining vulnerable and tolerant varieties and developing a trapping system to assess risk early on. Some varieties were shown to be resistant and gave a yield advantage of at least 2t/ha when heavily challenged by the pest. As well as resistance, some varieties were found to be more, and others less, vulnerable to damage than most others. Susceptibility was shown to depend on several genes and a mechanism for testing these traits was developed. Pheromone traps were developed through to a marketable product and the numbers of males caught were correlated to the level of egg-laying by females. However, risk of migration from other fields and suitability of weather for egg laying varied among sites. A further project has been commissioned.

Project Instigation:

- The project came from discussions with farmers about their problems with orange wheat blossom midge.
- The lead researcher asked the manager of one of the seed companies to involve other seed companies. He chose companies that he knew he could work with.
- Some of the members of the consortium had worked together before.
- Unfortunately the researcher that was to be looking at the genetic side died before the start of the project so other researchers had to be brought in.

Involvement of farmers/other businesses:

- About 200 traps were sold to farmers once they had been developed. The traps were very popular. The farmers were asked to give feedback on the usefulness and performance of the traps. One farmer thought that the traps offered some indication of a midge problem but he would have liked some guidance on thresholds and the best course of action when midges were found.
- Tests on commercial farms were run by consultants.
- The researchers and consultants also got feedback from farmers at field days.

Methods used:

- JIC looked at the genetics of the varieties and of attraction.
- Agrisense manufactured the trap.
- Rothamsted looked at the pheromones for the traps. Initially they looked at attractants, then traps were given to the trial sites and plant breeders and in the final year farmers were given the traps. The traps were tested in the field of wheat and at varying distances away.

- Variety susceptibility was tested at an ADAS and a TAG (The Arable Group) site with plot trials. Factors studied included midge activity and variety flowering time.
- One of the breeders said that they had done more trials and tests than were originally costed into the project.

Analysis:

- Most data on the varieties was handed to the lead researcher at ADAS to analyse. A statistician at ADAS was also involved.
- Other institutions analysed their own datasets.

How the project ran:

- It was a good team and all participants gave their views.
- There were some conflicting interests among the seed companies and chemical manufacturer and some sensitivity about commenting on some varieties in terms of midge susceptibility.
- The researchers got on well with those at the TAG site at Morley.
- It was thought that the project was successful because each component of the consortium knew what aspect they were working on and what they were doing. Another reason may have been that it was a very timely project.
- The project chairman was one of the breeders. This may have helped to keep the project relevant to farmers.

Outputs:

- HGCA and Defra project reports.
- One peer-reviewed paper has been published and others are in the pipeline. It was difficult to decide where to publish the results as the work covers different disciplines.
- The results were distributed to others around the world working on the same topic.
- There was a conference on the subject in March 2005 run by the lead researcher.

After the project:

- Another LINK project was funded, following on from this one with the same consortium.

Other issues:

- One farmer mentioned that he would like to see more near market research like this project.

Case 7. Project Title: Birdseye Unilever Sustainable Farming Partnership

Short Title (For the purposes of this report): Unilever

Duration: Ongoing

Lead Organisation: Birdseye Unilever

Funder: Birdseye Unilever

Project Summary: This project is funded by the Unilever's sustainable agriculture programme and involves research on the farms of pea growers and is also carried out on Unilever's Colworth estate in Bedfordshire by in-house researchers and external partners. There are three main objectives to this project. The first is to measure the long-term impact of current farm practice (Normal Agricultural Practice – NAP) compared to an extreme alternative (Extreme Agricultural Practice – EAP). Both EAP and NAP are flexible and change with accumulated knowledge. The variables tested through NAP and EAP included rotation, pesticides, fertilisers, crop timing (winter vs. spring) and margin management. The second objective is to assess and improve biodiversity and the third to understand the economic consequences and implications of the EAPs through the development of a cost model. The project is ongoing.

Project Instigation:

- The sustainable agriculture programme was started in 1999 and then in 2001 sustainable agricultural research was started with money from the corporate side of Unilever.
- Statisticians were involved in the original design.
- Other organisations such as ADAS, BTO and CEH are brought in to do work on the experimental area.
- Birdseye Unilever is reliant on agriculture for many of its products. The project is part of Unilever's corporate social responsibility.

Involvement of farmers/other businesses:

- The manager at the Birdseye Unilever farm at Colworth is involved in the day-to-day management of the experiments carried out there. However, he is not generally involved in the collection of data apart from yield data.
- Farmers who have a contract with Birdseye have to be part of their 'farmers forum'.
- Planning meetings involved farmers and other research partners.
- Colworth farm is open for anyone to visit. The farm manager carried out tours for Birdseye farmers and other groups.
- When farmers visited the Birdseye Unilever farm, the visual aspect was very important in determining what they thought of the treatments.

Methods used:

- Treatments applied were either 'normal agricultural practice' or 'extreme agricultural practice'. The experimental area is 80ha.
- Treatments were applied to quarter- and half-fields.
- Experiments were to be scaled down to plot experiments if they detected an effect they were interested in. However, the resources were not available for this.
- The external organisations doing trials on the experimental area carried out their own measurements and analysed their own data.

Analysis:

- A statistician at Colworth (Birdseye Unilever site) is involved in analysing the data.
- Few significant effects were found. However, one researcher said that they did not think it was particularly important for effects to be significant. This was confirmed by one of the farmers. It was felt that practical tools for farmers were more important.

How the project ran:

- It was thought that the biggest challenge of the project was to have a true partnership rather than the different partners working separately.
- It is challenging for those working on the sustainable agriculture programme to keep the long term funding for the farm and maintain the interest of others in the business not directly involved in the food aspect.
- It was important that farmers were happy with the research and would not lead to problems e.g. farmers were worried that Birdseye Unilever would use the research to lower the pea price.
- There were differences of opinion about the design of the experiments between research partners and agronomists involved.

Outputs:

- Recommendations for improved practice were required outputs.
- A report is currently being written by the researchers at Birdseye Unilever with the other project partners.
- When presenting results, gross margins are always shown.
- Birdseye Unilever were not interested in writing peer-reviewed papers, but were happy for the other organisations involved to do so.

After the project:

- The project is ongoing.

Other issues:

- It is hard to sell stories of sustainability to consumers.
- Birdseye Unilever are also involved in other projects with research institutes and universities. Some of these are being conducted at Colworth farm.
- The nearest most farmers get to scientists are agronomists.
- One farmer said that more near market research was needed. He thought that research had gone from being production linked to defending what farmers were doing.

Case 8. Project Title: Improving N use and performance of arable crops on organic arable farms using an expert group approach

Short Title (For the purposes of this report): ADAS expert group project

Duration: 2 Years 11 months (01/01/1999 – 01/12/2001)

Lead Organisation: ADAS

Funder: MAFF

Project Summary: The objective of this project was to enhance the productivity of organic arable systems by identifying changes that could be made to increase nitrogen availability and decrease nitrogen losses from the system using an 'Expert group' approach. This was done by looking at 9 case study farms and calculating nutrient budgets for these farms. These were then studied by experts in organic farming, nutrient management and crop physiology along with information taken from the literature, who made recommendations of strategies that could improve the nitrogen efficiency of organic farms. They concluded that small improvements in efficiency of nitrogen use in organic systems could lead to large improvements in output. These messages were disseminated to the organic farming community through presentations and a booklet.

Project Instigation:

- It came from a MAFF (now Defra) funded open competition.
- It involved experts on organic farming, nitrogen management and crop physiology from different institutions (ADAS, University of Nottingham, Elm Farm Research Centre). The experts knew each other before the start of the project.
- The team changed over the course of the project. One researcher involved in the concept handed over to another researcher when the project started.
- Rather than carrying out an experiment it was felt that there was enough information in nitrogen management available that could be refined for the organic system.

Involvement of farmers/other businesses:

- Farmers were approached after the project had been funded. Some had had a relationship with the research institutions before and had been involved in other research projects as well as their own unofficial research.
- Nine organic farms were used as case studies. They gave researchers information about their farming system and also their field records. The farms included 1 ADAS farm and Elm Farm, because more information was available about them.
- The farmers were invited to meetings with researchers.
- It was difficult for the farmers to find time to help the researchers.

Methods used:

- Literature review.
- Data including field information (e.g. soil types, rotations, manure inputs) and farm information was collected from nine case study farms.
- A nutrient budget was carried out using management information and soil, crop and manure measurements, and losses through leaching and volatilization.
- The 'Expert Group' approach whereby the experts met at least twice a year to discuss nutrient management strategies.

Analysis:

- The expert group developed alternative strategies for nutrient management.
- Nitrogen, phosphorous and potassium budgets were calculated for each farm and nitrogen losses calculated using models (NITCAT and MANNER).
- Nutrient management strategies were reviewed with farmers and amended.

How the project ran:

- The project ran smoothly, with regular meetings.
- It took up more time than expected so the project was under-costed.
- One of the researchers was concerned about how the farmers would react to his background and opinions concerning organic farming.
- Farmers were very vociferous at the meeting to discuss the strategies and rejected some of the researchers' suggestions.

Outputs:

- A booklet on nutrient management was written for farmers/advisors. This was changed as a result of the meeting with the farmers.
- One researcher mentioned that they thought that the booklet wasn't as good as other project leaflets.
- The farmers interviewed thought the booklet was very useful although one mentioned it hadn't caused them to change their practice significantly.
- Peer-reviewed papers were written as the researchers were keen to do it and ADAS encouraged this as a form of promoting their work. The RAE did not concern the researchers involved
- Presentations at conferences.
- Training day for organic advisors

After the project:

- It was not discovered whether the case study farmers carried out any of the recommendations.
- The group hasn't worked together on a project since.
- The funder liked the approach the project took and subsequently funded two other participatory projects.
- It was thought that in participatory projects it takes a long time to build up relationships and good communication.

Other issues:

- Farmers were pleased when researchers came on to their farm.
- One farmer thought that some projects don't result in a change in agricultural practice because farmers won't change unless it results in a substantial effect on their business.
- Farmers were willing to be involved in further research, but mentioned that their involvement should not add extra time.

Case 9. Project Title: Qualitative assessment of behaviour as a method for the integration of welfare measurements.

Short Title (For the purposes of this report): SAC pig welfare project

Duration: 01/10/01 to 30/04/05

Lead Organisation: SAC

Funder: Defra & SEERAD

Project Summary: Previous SAC research developed a method of assessing animal behavioural expressions which had the potential to be a tool for integrating different scientific approaches to animal welfare. This involved 'free choice profiling' (FCP), which gives observers freedom to choose their own descriptors of welfare, which is then analysed with generalised Procrustes analysis (GPA), a multivariate statistical technique. The aim of this project was to 'develop the potential of the FCP/GPA methods to integrate different types of biological data relevant to animal welfare, in a range of studies'. Here we refer to one of these studies, whose objective was to apply the FCP/GPA approach to on-farm welfare assessments. Vets were introduced to the FCP method and then taken to a range of pig farms where the welfare of the pigs was assessed.

Project Instigation:

- The lead researcher had been working on pig welfare for 10 years.
- This study was part of a 3 year project funded by Defra and SEERAD.
- The lead researcher had already developed a method for welfare assessment and this project was designed to test the effectiveness of the assessment.

Involvement of farmers/other businesses:

- The state veterinary service was involved. Vets were asked to volunteer to be part of the project.
- Farmers were asked if vets could assess the welfare of their pigs. The farms involved varied from small outdoor herds to large intensive systems.
- With the smaller farms the researchers generally interacted with the farmers whereas with the larger farms the stockman was generally the contact.
- Farmers thought that the researchers and vets had listened to their opinions on the welfare of their pigs.

Methods used:

- A preliminary meeting was used for vets to come up with descriptors to describe pig welfare using video footage of pigs, which the researcher had previously taken from the farms involved.
- The vets gave suggestions of how the method could be improved.
- The researchers and vets then went onto farms, assessed the pigs and then met with farmers to discuss the welfare of their pigs.

Analysis:

- When the vets had assessed the pigs, the scores were given to the lead researcher to examine.
- One of the vets said that although they were told how the data was to be analysed, they didn't really understand the method.
- The scores the vets gave the welfare on different farms were analysed.
- Talks with farmers were summarised.

How the project ran:

- The project ran well and was positive.

- It was made clear to the vets that they should not judge the farmers.
- The lead researcher enjoyed talking to farmers and interacting with the vets involved.
- Initially the vets were wary that the assessment was subjective but eventually they realised it was information that they could use.
- Farmers found it interesting to stop and look carefully at the pigs with the vets. They said it was something farmers don't generally have time to do.
- One of the vets thought that it was a useful method to explain welfare assessment to others or at a student level. However, they said that they would not necessarily use it themselves.
- The vets thought that the method gave them a framework to a technique they use anyway.

Outputs:

- The final project report has been written for Defra and SEERAD.
- A report has been written for the participants of the project.
- The results have been presented at conferences.
- Peer-reviewed papers are being written.

After the project:

- The researchers want to now develop a system of assessment usable for vets
- The lead researcher is part of a European network developing a standardised on-farm welfare monitoring tool.
- They have been approached by QA organisations asking if their inspectors can use the methods resulting from the project.
- The vets found that on subsequent farm visits farmers thought the method was interesting.
- One of the farmers said that the project made him look at his pigs more.
- Both the vets and farmers interviewed said that they would be happy to be involved with another project. However, one farmer said that any project should not take up too much time or involve much paperwork.

Other issues:

- The lead researcher has been given a year to write papers without having to work on other projects
- One of the farmers said that other farmers in the area were astonished that he had let so many vets on his farm.

Case 10. Project Title: Constraints to uptake of adequate biosecurity on UK cattle and sheep farms, with special reference to zoonotic diseases

Short Title (For the purposes of this report): VEERU biosecurity project

Duration: 1 year, 6 months (June 2002 - December 2003)

Lead Organisation: University of Reading

Funder: Defra

Project Summary: The main objective of this study was to identify issues considered to be key constraints and incentives to uptake of better biosecurity measures on cattle and sheep farms by veterinarians, members of livestock auxiliary industries (e.g. markets, hauliers), other stakeholders (e.g. levy bodies, tourist industry) and the farmers themselves. This was done by conducting farmer focus groups including studies of farmer attitudes based on the Theory of Reasoned Action (TORA), and surveys of the other groups mentioned above. The project also looked at costs and benefits of implementing biosecurity measures and constraints to the uptake and adherence to animal health schemes offering accreditation for disease freedom or monitoring. The project concluded that the different stakeholders did little to collaborate with biosecurity measures and often had negative perceptions of each others contribution to the common cause of biosecurity.

Project Instigation:

- Defra wanted to know the difficulties of implementing biosecurity measures to provide evidence for policy makers. There had been concerns within Defra that on-farm biosecurity could be improved. Therefore they put the question in to an annual call for proposals.
- Defra would have liked to look at the effectiveness of biosecurity measures but they are long term projects and farmers often change their business. It is also hard to get farmers involved as they don't want to be identified as having a particular disease problem
- The project was a new area for Defra as studies were usually concerned with a specific disease.
- The work was commissioned before the Foot and Mouth outbreak but interest in the project increased after the outbreak.

Involvement of farmers/other businesses:

- Farmers were involved in focus groups which were carried out throughout the country. It was decided which farmers should be involved through the MDC, MLC and milk recording groups.
- Consultants were often used to set up the focus groups.
- In-depth interviews were also carried out with farmers who were, or were not, members of a health scheme. These were generally in Scotland.
- Veterinarians were surveyed
- Members of the livestock auxiliary industry were surveyed. These included representatives of haulage companies, feed companies, markets, tourist organisations and levy bodies.

Methods used:

- Focus groups. These were carried out because the project budget was small. Specialists were brought in to facilitate focus groups.

- Questionnaires were sent to cattle and sheep vets and British Cattle Veterinary Association members.
- 28 auxiliary industry organisations were interviewed over the telephone.

Analysis:

- The focus group discussions were transcribed and the text was coded. The codes were then analysed using the Theory of Reasoned Action (TORA) as a framework.
- A cost: benefit analysis of carrying out biosecurity measures was carried out on 20 farm case studies.

How the project ran:

- Trust by farmers was an important aspect in how the project ran, as was the existing relationship the researchers from differing institutions had.
- Farmers enjoyed the focus groups and said that it forced them to think.
- It took the natural scientists time to get used to dealing with qualitative data, but once mastered, they were impressed by what information could be gained.

Outputs:

- Reports to Defra.
- The researchers have fed back conclusions to farmers.
- Peer-reviewed papers have been published.

After the project:

- The work lead to other projects.
- Farmers contacted the researchers wanting to know what Defra would do with the conclusions.
- One of the researchers has moved away from quantitative work as a result of this project

Other issues:

- One of the researchers thought that the term participatory is creeping into UK research projects.
- One of the farmers has been involved in other research projects and a discussion group and feels he has learnt a lot from them.
- One of the farmers felt that British agriculture has a poor record in disseminating results. He felt that academics aren't always good at delivering information to farmers.