AGRICULTURAL ADVISERS AND THE TRANSITION TO SUSTAINABLE SOIL MANAGEMENT IN ENGLAND:

AN ANALYSIS OF THE ROLE OF KNOWLEDGE AND KNOWLEDGE PROCESSES

JULIE ANNE INGRAM

A thesis submitted to
The University of Gloucestershire

in accordance with the requirements of the degree of
Doctor of Philosophy in the Countryside and Community Research Unit

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I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by special reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed [redacted].. Date ....23/5/05........

Abstract

This research is concerned with the dynamic relationship between agricultural advisers, knowledge and soil in England. On the basis that agricultural advisers have always played a central role in linking research and farming practice and implementing policy on the farm, the thesis explores the role of the adviser in facilitating a shift towards sustainable soil management (which encompasses a range of complex and knowledge intensive practices) and to the realisation of policy objectives in this domain. Specifically it aims to provide detailed empirical evidence of the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about soil best management practice and to elicit the factors that enable and constrain these knowledge processes. Conceptually, the research draws on approaches to knowledge and knowledge processes in agriculture from the allied disciplines of rural geography, rural sociology and extension science. An actor-oriented Agricultural Knowledge and Information System (AKIS) approach provides the basis for examining adviser interactions with both the research and farming communities. While the AKIS describes the factors that enable and constrain how advisers engage in knowledge processes in terms of connections across institutional interfaces between research, advice and farming, an actor-oriented approach, which understands knowledge processes as social processes operating across social interfaces, enables exploration of how individual advisers behaving as autonomous agents resolve these constraining and enabling factors.

The study, combining quantitative and qualitative methods, employs an extensive postal questionnaire survey of a 163 agricultural advisers from across England and three detailed case studies where sustainable soil management is a central theme, namely: the Landcare Project; the UK Soil Management Initiative; and the SUNDIAL Fertiliser Recommendation System. The data describe an advisory community with a range of involvement, concerns and competence in soil management. Patterns of acquisition and utilisation of knowledge about soil best management practice revealed by the questionnaire data suggest that advisers are actively seeking and using knowledge about soil management, although some are more constrained than others in accessing it. These patterns, however, only provide a partial understanding of the complex knowledge processes in which advisers engage as they operate at the boundaries between science and practice. As such, qualitative data from the case studies are used to reveal that, in bridging the different institutional cultures and life worlds of research and practice, advisers encounter different understandings and expectations of soil best management practices. Rather than simply acquiring, utilising and transferring knowledge, the data reveal that advisers negotiate, adapt, transform, generate and integrate knowledge about soil as they struggle to reconcile the principles of research-based soil best management practice with the practical and business constraints of the farm. In doing this advisers, and agronomists in particular, tend to closely align themselves with the interests of the farming community and as such are more likely to reject or question soil best management practice. In addition the apparent lack of advisers' competence and skills in certain knowledge intensive soil best management practices and their reliance on experiential knowledge further explains their reluctance to engage in soil best management practices derived from national research. Integration of knowledge through dialogue and understanding emerges as key to overcoming these tensions and providing the basis for facilitating sustainable soil management. Advisers are shown to have a central role in integrating knowledge from research and from farmers. The processes and relationships that enable this integration are identified.

The thesis concludes with some policy relevant suggestions to improve the effectiveness of advisers' participation in the transition to sustainable soil management in England. These include: exploiting a diverse and flexible advisory community; improving advisers' skills and expertise; instilling in them confidence to provide credible and practical soil best management practice; and improving the quality of communication between the advisers, researchers and farmers. Future research directions are reviewed in the context of the proposed implementation of Soil Management Plans on all farms in England as a component of cross compliance within CAP reforms.

Acronyms and Abbreviations

AICC	Association of Independent Crop Consultants
AKIS	Agricultural Knowledge and Information System
AKS	Agricultural Knowledge System
APO	Assistant Project Officer
ARC	Arable Research Centre
BBSRC	Biotechnology and Biological Sciences Research Council
BIAC	British Institute of Agricultural Consultants
BSSS	British Society of Soil Science
CAP	Common Agricultural Policy.
CCS	Countryside Stewardship Scheme
CCW	Countryside Council for Wales
CoGAP	Code of Good Agricultural Practice
CPA	Crop Protection Association
CPRE	Council for the Protection of Rural England
cwt/acre	hundred weight per acre
DEFRA	Department of Environment, Food and Rural Affairs
DETR	Department of Environment, Transport and the Regions
DoE	Department of Environment
DSS	Decision Support System
EA	Environment Agency
EN	English Nature
EPO	Environmental Protection Officer
ERDP	English Rural Development Programme
ESA	Environmentally Sensitive Area
EU	European Union
FACTS	Fertiliser Advisers Certification and Training Scheme
FAS	Farm Assurance Scheme
FoE	Friends of the Earth
FRS	Fertiliser Recommendation Scheme
FWAG	Farming and Wildlife Advisory Group
GAEC	Good Agricultural and Environmental Practice
GCT	Game Conservation Trust

HGCA	Home Grown Cereals Authority
IACR	Institute of Arable Crops Research
ICM	Integrated Crop Management
IFS	Integrated Farming Systems
IGER	Institute of Grassland and Environmental Research
IPSS	Institute of Professional Soil Scientists
JNCC	Joint Nature Conservation Committee
kg	kilogram
kg/ha	kilograms per hectare
MAFF	Ministry of Agriculture, Fisheries and Food
MGA	Maize Growers Association
MRC	Morley Research Centre
N	Nitrogen
NERC	Natural Environment Research Council
NFU	National Farmers' Union
NSRI	National Soil Resources Institute
NT	National Trust
NVZ	Nitrate Vulnerable Zones
OAS	Organic Advisory Service
OECD	Organisation for Economic Co-operation and Development
P	Phosphorus
PC	Personal computer
PO	Project Officer
RASE	Royal Agricultural Society of England
RDS	Rural Development Service
SI	System International
SMI	Soil Management Initiative
SMP	Soil Management Plan
SNH	Scottish Natural Heritage
SSLRC	Soil Survey and Land Research Centre
TAG	The Arable Group
UKASTA	UK Agricultural Supply Trade Association

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Chapter 1

SOILS AND SUSTAINABILITY: NEW CHALLENGES FOR AGRICULTURAL ADVISERS

1.1 Introduction

This thesis is concerned with the relationship between soils, agricultural advisers and knowledge. Sustainable management of the soil resource is essential for societal well being because although it is a physical resource, soil cannot be divorced from people. For most people soil is much more than the standard soil scientist's definition of a 'complex media composed of mineral particles, organic matter, water, air and living organisms, together with the fluxes of substances and fluids between these elements' (European Environment Agency (EAA) 2000a: 1). Cultural constructs of soil, which include terms like 'mother earth' and recurrent themes in literature (Zola 1887; Balzac 1998) demonstrate our deep relationship with the resource, as do our emotions of attachment and patriotism to the soil when viewed as synonymous with 'land'. The organic movement attribute particular value to sustaining the soil resource seeing it as part of the trinity 'healthy soil, healthy plants, healthy people' as conceived by Lady Eve Balfour (1943), founder of the Soil Association. Similarly its loss, degradation or mismanagement call forth notions of violation. Steinbeck (1976: 46) for instance in *The Grapes of Wrath* describes 'harrows combing with iron teeth .... raping methodically, raping without passion'. This reverence demonstrates that our attachment to soil far exceeds its worth as simply a medium for plant growth or as a foundation material for building.

Changes in our understanding of the importance of soil, resulting from more advanced studies of ecosystems, reflect this much wider role and attribute a range of fundamental social, environmental, economic and cultural functions to soil. These include food and other biomass production, a filter for drinking water and buffer for pollutants, a source of raw materials for human use and a physical and cultural environment for mankind as an integral part of heritage and landscape reflecting present and past natural and human activities (Blum 1993). These functions highlight the essential role of soil as a 'life support system' (British Society of Soil Science (BSSS) 1997). They also demonstrate that we cannot detach the physical processes of the soil and the physical systems they operate in from the social systems that determine how they are used. In the agricultural context, it has long been recognised that soil degradation has social causes, from explorations of the political economy of soil erosion (e.g. Blaikie 1985) to socio-economic determinants of soil conservation behaviour (Napier et al. 1984). As Stocking and Murnaghan (2001: 25) state 'although land degradation is a physical process, its underlying causes are firmly rooted in the socio-economic, political and cultural environment in which land users operate'. The proliferation of interdisciplinary studies addressing problems of land degradation in developing countries are testament to the acceptance that soil science alone does not provide answers, and that an understanding of social science is equally important (Bouma 1997; Fairhead and Scoones in press). Similarly in the UK a causal link has been made between increased incidences of soil degradation and the activities of farmers responding to pressures and incentives of the Common Agricultural Policy (CAP) to farm more intensively (Boardman 1988).

At the same time the economic, environmental and social implications of mismanagement of soil to society are clear. In the UK social costs of flooding and siltation through poor soil management, exaggerated by more extreme weather events have recently hit the headlines. Incidents of damage to property by muddy run off from farmers' fields on the eastern South Downs have amounted to 138 in the period 1976-2001. These have been attributed to increased winter sown cereals and the associated intensive soil management practices (Boardman et al. 2003a,b). Such incidents have repercussions beyond the farm gate, costs to highway maintenance are growing and farmers have been prosecuted for letting soil wash onto roads[1]. Siltation from soil wash into rivers has caused salmon fisheries to suffer while lakes have needed dredging, sometimes at considerable cost. For example, the National Trust's have spent in excess of £100,000 in removing silt from a lake on the Arlington Estate[2]. Claims that the widespread flooding of autumn 2001 was due as much to

[1] A fatal traffic accident attributed to hazardous mud spilling onto the road from a sugar beet farm resulted in the farmer facing a manslaughter charge; the first instance of such a charge relating to highways (Farmers Weekly 2002).

[2] The lake has accumulated 18,000m^3 of silt since desilting 10 years ago.

poor soil infiltration of compacted agricultural soils as to extreme weather events also highlight soil management as a societal issue (Boardman 2001). It is now accepted that increased nitrates in drinking water and eutrophication of waterways result when both organic and inorganic fertilisers leach from soils. This represents a further soil management problem that brings public concern in terms of damage to the environment, pollution of drinking water and costs for water authorities. The repercussions and costs for society if these incidents continue are clear.

Despite the importance and growing prominence of these issues, soils arguably represent an agri-environmental 'lag issue' in the UK. Public understanding and interest in soil is limited as it is among the farming community and industry. With respect to rural social science in UK, soils have remained an 'unseen' factor on the farm, and when compared, for example, to nature and landscape conservation, interest in soils has been insignificant. Little concern has been shown toward the protection of soil itself through policy or regulation and this contrasts markedly with air and water pollution, which have received considerable policy attention and regulation. However, this situation is now changing. Recognising increasing threats to the soil resource in UK, in 1996 the Royal Commission for Environmental Pollution's (RCEP) report *Sustainable Use of Soil* (RCEP 1996) recommended a soil protection policy for UK with the protection of agricultural soils as a key component. Following this the government published *A Draft Soil Strategy for England – a Consultation Paper* (DETR 2001) which sets out how the government intends to promote the sustainable use of soils by integrating existing policies and legislation. This strategy is seen as part of a wider commitment by the government to sustainable resource use, as reinforced in the recent farming and food strategy for England *Facing the Future* (DEFRA 2002a). More recently the publication of the *First Soil Action Plan for England* (DEFRA 2004a), which outlines the key actions the government needs to take to protect soil, together with a number of other key documents (Environment Agency 2004a,b) herald a new era of concern for the soil. Most significantly a Soil Management Plan for each farm will be central to measures of 'Good Agricultural and Environmental Condition' (GAEC), which has been proposed as a standard against which to measure compliance with the single farm payment in the latest CAP reforms (DEFRA 2004b).

The multifunctional role that soil plays also means that its management is integral to environmental protection and pollution prevention (MAFF 2001b). With the EC Water Framework Directive's strong focus on diffuse pollution and with more than 50% of England designated as Nitrate Vulnerable Zones, more pressure through regulation is expected to be applied to farmers to manage their soils and take effective action to control soil, pesticide and nutrient losses in many vulnerable catchments (DEFRA 2004d,e). All these developments emphasise the desirability of a shift towards the more sustainable 'best management practice' of soil as set out in the *Soil Code* (MAFF 1998b).[3]

Within these policy developments emphasis is being placed on increasing the amount of advice and 'knowledge transfer'[4] to farmers in the recognition that, as Garforth et al. (2003) note, information and advice are important tools in the achievement of policy objectives. The need for support through advice and information was identified in the RCEP report which recommended that the agriculture departments promote ways of improving contacts between farmers, advisers and the research community and that free advisory visits on pollution prevention and conservation should continue and should include advice on appropriate measures for the more sustainable use of soils, including the control of erosion (RCEP 1996: 78). Other organisations have similarly pressed for better advisory provision for farmers to support them in protecting soil (Winter and Murray 1998; Environment Agency 2004a). More recently the Policy Commission on Food and Farming (DEFRA 2002a) identified a need for improving land managers' skills in best management practice to protect natural resources and following recommendations, a pilot network of demonstration farms has been initiated and the Learning Skills and Knowledge review is currently looking at how information can be supplied to land managers.

[3] *The Code of Good Agricultural Practice for the Protection of Soil* (MAFF 1998b). Along with Codes for the protection of air and water, the Soil Code is sent to all farmers. There is no legal commitment to adhere, although compliance is required for Farm Assurance Schemes (FAS) and agri-environmental schemes.

[4] The term 'Knowledge Transfer' is a problematic term and will be addressed more fully in subsequent chapters. Its use in this sense is to imply communication of policy objectives and associated practices to farmers, as Garforth et al. (2003: 326) state 'Knowledge transfer' may be the convenient shorthand for a process in which knowledge generated by research is integrated with technology used within the agricultural industry'.

The planned introduction of Soil Management Plans as part of the GAEC will make new demands on farmers, something recognised by (DEFRA 2004b) and the agricultural community as whole; as Professor Godwin of the National Soil Resources Institute (NSRI) recently remarked 'To maintain GAEC, farmers will need advice and guidance to help them assess their land to identify problem areas and select measures to tackle issues such as curtailing erosion, minimising run-off and managing soil compaction' (Farmers Weekly 2004a). Similarly DEFRA acknowledge that 'catchment-sensitive farming' which has been proposed to combat diffuse pollution will require additional advisory support (DEFRA 2004e). The European Union's requirement for every member state to have its own farm advisory service by 2007 acknowledges that farmers need support in meeting the challenges that accompany CAP reforms. Such a service will need to be equipped to provide advice on what constitutes GAEC and understand the requirements of the new agri-environmental schemes and regulation. In light of the recent settlement on the CAP reform, the Haskin's Review of Rural Delivery (DEFRA 2003a) recommended the creation of a farm advisory service and highlighted the need for co-ordination of information, regulation, and compliance support for farmers. DEFRA's response, the *Rural Strategy* (DEFRA 2004f) proposes a new advisory package to support the introduction of the cross-compliance requirements. These initiatives are based on an understanding that advice to farmers is crucial to achieving sustainable farm practices. Agricultural advisers are central to providing this advice.

Advisers play an important role within the broader 'Agricultural Knowledge System'[5] (AKS) existing as they do at the centre of the advisory process and providing an essential connecting role at the interfaces or points of linkage between research, and the policy that informs it, and practice. The agricultural adviser has always been an important and influential actor on the farm. The District Advisory Officer (DAO) of the National Agricultural Advisory Service (NAAS) and its successor the Agricultural Development and Advisory Service (ADAS) were an important component of the state advisory service during the productivist years (1950-1980s) helping farmers exploit opportunities to improve economic efficiency

[5] Agricultural advice is part of a complex system of policy makers, research institutes, extension and advisory services, NGOs and commercial companies, consultants and farmers and their organisations, which interact and enable information exchange. This complex is called the Agricultural Knowledge System. Further consideration of this, and related terms, will be given in Chapter 3.

through the delivery of specialist technical advice (Dancey 1993). Agricultural advisers have also been influential in assisting policy makers in the implementation of policies and in changing farmer behaviour (van den Ban and Hawkins 1996; Long and van der Ploeg 1989; Rogers 1995). Those commenting on the implementation of agri-environmental policies in the UK recognise this (Baldock and Mitchell 1995; Cooper 1999). For example, it was found that, of all the external factors that affected farmers' decisions to convert to organic farming, the impact of the organic advisory service was most significant (Burton et al. 1999). Similarly the success of agri-environment schemes, such as Environmentally Sensitive Area (ESA) and Countryside Stewardship Scheme (CSS), has been shown to be critically dependent on the work of project officers or other advisers promoting the scheme (Cooper 1999; Juntti and Potter 2002). The advisers' role has also been key in the success of free pollution advice provided through the Farm Waste Management Programme (FWMP) and point source regulations (ECOTEC 2000). Of all methods of communication, the individual farm visit by an adviser remains one of the most powerful and effective, and is most valued by the farmer (Jones et al. 1987; Eldon 1988; Roling 1988; Cox et al. 1990; Fearne 1991; Angell et al. 1997; ADAS 2000b). Agricultural advisers, by visiting the farm, are well placed to support the farmer in the context of local soil conditions, and farmers particularly value the interpretation of information at the farm level (Jones et al. 1987; Dampney et al. 2001). The growth in numbers of independent, commercial and FWAG advisers is further testament to the value farmers give to on-farm face to face advice in England.

1.2 Research aims and objectives

Given these factors it is important to explore whether agricultural advisers can play such a key role in facilitating sustainable soil management and therefore contribute to the realisation of policy objectives outlined above. In testing advisers' adequacy, or fitness for purpose, it is important to explore the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about soil best management practice; and what influences the ability of advisers to play an effective role in these processes and their active and purposive engagement in knowledge interactions in this context.

This research aims to examine critically the dynamic relationship between agricultural advisers and knowledge in the context of the development of sustainable soil management in England. Specifically the objectives are:

- To provide detailed empirical evidence of the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about sustainable soil management;

- To elicit the factors that enable and constrain these knowledge processes;

- To make a contribution to the conceptualisation of Agricultural Knowledge Systems surrounding sustainable soil management in England;

- To make policy relevant suggestions for improving the operation of the Agricultural Knowledge System in order to achieve more sustainable soil management.

The thesis is structured as follows:

Chapter 2 provides the context for the research. The nature and importance of soil as a resource is elaborated with reference to soil's multifunctional role; the threats to the soil resource and the need for protection and sustainable management are identified. Policies and the associated research priorities that relate to soil protection in England are reviewed and the development of 'best management practices for soil' as a platform for achieving policy objectives at the farm level are discussed. The critical role of the advisory community in facilitating these practices on-farm is considered in relation to the nature of the Agricultural Knowledge System.

Chapter 3 provides the conceptual framework for the thesis. Conceptualisations of knowledge processes, which have developed in the context of agriculture, are reviewed. Those perspectives, which allow both an understanding of the advisers' role in knowledge processes and the factors that enable and constrain these processes, are elaborated in the context of achieving sustainable soil management in England. This discussion contributes to the development of a conceptualisation of advisers' knowledge processes in the Agricultural Knowledge System in England in relation to soil management.

Chapter 4 details the methodology employed in this study. It presents a justification for using a combination of quantitative and qualitative methods and describes in detail the activities involved in conducting an extensive postal questionnaire survey of agricultural advisers and carrying out three detailed case studies.

Chapters 5 to 7 present the results from the research. Chapter 5 is concerned with the role that agricultural advisers play in the acquisition of knowledge about soil best management practice at the interface with research. It presents results from the questionnaire about advisers' preferred mechanisms and sources for information from the research community and combines this with an analysis of advisers' interactions with researchers in the context of a case study. Chapter 6 presents data concerning the advisers' knowledge interactions with both the research and practical community; it provides questionnaire data on advisers' utilisation of research outputs and describes results from two case studies. Chapter 7 presents data concerning the advisers' diverse interactions with the farming community and the impact these have on exchanging knowledge about soil management.

Chapter 8 provides a discussion of the results in the context of the research objectives and then examines these results with reference to the conceptual framework elaborated in Chapter 3. It endeavours to provide further contributions to the development of conceptualisation of Agricultural Knowledge Systems surrounding sustainable soil management in England. Policy relevant suggestions for improving the operation of the AKS in order to achieve more sustainable soil management in England are also outlined.

Chapter 2

THREATS TO THE SOIL RESOURCE AND COUNTER MEASURES TO SUPPORT SUSTAINABLE SOIL MANAGEMENT

This contextual chapter begins by outlining the nature of soil, it goes on to review the literature on the threats to sustainable soil use in the UK and the development of policies, research and practical initiatives to counter these. In particular it elaborates on the role of the advisory community in England in delivering policy objectives and considers the potential of agricultural advisers in facilitating sustainable soil management on farms.

2.1 The nature of soil

Soil is typically defined by soil scientists as the top layer of weathered skin on the earth's crust. It is composed of mineral particles, organic matter, water, air and biota. Soils vary considerably in their characteristics depending on the rock from which they were derived and conditions under which they were formed. They differ in depth, physical structure, texture, water content, proportion of organic matter and chemistry and these differences affect the fertility, soil processes and flora and fauna. Soil is conventionally characterised and classified by the texture and the nature of material from which it has developed. As well as being vertically heterogeneous, soil varies spatially, within England and Wales alone 700 specific types of soil can be identified (Clayden and Hollis 1984).

Soil, along with water and air, is one of three essentials of life on land. It is a basic agricultural and rural land use resource and is an integral part of the landscape and its component ecological processes, continuously interacting with the atmosphere, biosphere and geosphere. Soils not only provide a medium for plant growth but also exist as dynamic, evolving ecological systems subject to natural and human induced changes. They perform a wide range of fundamental social, environmental, economic and cultural functions, which may or may not be mutually exclusive. The following soil functions are distinguished by Blum (1993):

- Food and other biomass production. Agricultural and forestry production is totally dependent on soils; vegetation needs soil to supply water and nutrients and to fix roots.

- Filtering, buffering and transformation. Soils store and partly transform minerals, organic matter, water, energy and diverse chemical substances. Soil functions as a natural filter for groundwater, it is the main source of drinking water, and it stores carbon and releases CO_2, methane and other gases to the atmosphere.

- A biological habitat and gene reserve. Soil is the habitat for a huge amount and variety of organisms living in and on the soil, all with unique gene patterns.

- Physical and cultural environment for mankind. Soil is important as a platform for human activity, as an integral part of heritage reflecting present and past natural and human activities, and as an element of landscape.

- A source of raw materials for human use.

Soil heterogeneity results in each soil having its own characteristic signature in terms of its ability to fulfil the entire range of these functions.

2.2 Threats to soil in the UK

Natural processes and human activities contribute to soil's dynamic and evolving character. However, human activities can result in the impairment of ecologically essential processes, reduction in productive capacity or depletion of soil quality and biodiversity. When soil loses its capacity to carry out these functions, soil degradation results. This is an increasing problem recognised internationally (Blaikie and Brookfield 1987; World Resources Institute 2000) as well as within Europe. In the EU, for example, an estimated 52 million ha (16% of land area) are affected by some kind of soil degradation process (Global Assessment of Soil Degradation (GLASOD) 1990; van Lynden 1995). Erosion, acidification, accumulation of pollutants, loss of organic matter and soil compaction all threaten the UK soil resource and its functions (MAFF 1970; Beard 1989; Howard and Hornung 1989; Council for the Protection of Rural England (CPRE) 1994; Thompson and Peccol 1995; RCEP 1996; Environment Agency 2004b). Although these threats affect soil under a range of land uses, concern has focused on agriculture. Agricultural soils are not in a natural state but have been extensively modified through human use and there is growing evidence that agriculture is having a detrimental impact on soil (RCEP 1996; Skinner et al. 1997; DETR 1998a; Joint Nature Conservation Committee (JNCC) 2002; Environment Agency 2004b). Most of these impacts are classified as irreversible within the human time scale (Auerswald and Kutilek 1998; EAA 2000a).

Decline in soil quality in the UK has been largely attributed to intensive arable farming encouraged by the Common Agricultural Policy (CAP) where farmers reacted positively to support payments during the 1970s and 1980s (Boardman 1990; CPRE 1994; Baldock and Mitchell 1995; RCEP 1996; DETR 1998a; Boardman et al. 2003a). An emphasis on efficient food production has encouraged continuous arable cropping, winter cereals, increased cultivation with heavier machinery, ploughing up of pasture, minimal rotations, the inappropriate use of marginal lands which are more sensitive to degradation, and overgrazing in upland areas all resulting in negative consequences for the soil (Baldock and Mitchell 1995; DETR 1998a; JNCC 2002).

Cultivation with large machinery, together with the loss of rotations, has caused physical degradation to the soil, which affects all soil functions and can bring about long-term changes to soil structure[6] which are hard to reverse. Use of larger machinery under unfavourable weather conditions leads to compaction of topsoil and

[6] Soil structure is the aggregation of soil particles into 'peds'. These are normally clods of earth held together in shapes varying from platy to granular. The pores within peds and the spaces between them are vital for aeration and drainage. Unlike texture, structure changes naturally and through management. Maintenance of good stable structure in agricultural soils is vital as it affects infiltration (and therefore run off and erosion), aeration, water storage and drainage, mineralisation of organic matter, seed germination and crop growth.

subsoils, most marked are the plough pans[7] and compacted tramlines. This problem is accentuated where drainage is inadequate. Excessive cultivation to provide a fine seed bed can leave the surface soil vulnerable to slaking or capping[8] when exposed to rain and consequently at risk from erosion as described below. Long-term cultivation also leads to a loss of soil organic matter through oxidation. The *Strutt Report* (MAFF 1970) first identified widespread reduction in soil organic matter and found that a wide range of soils were suffering from the use of heavy machinery under unsuitable conditions. It concluded that many agricultural soils could not sustain the demands placed on them. More recently sampling in England and Wales found that the percentage of samples with organic matter below 3.6% was 40% in 1995, compared to 30% in the 1981, meaning that nearly half the samples were below the optimum level of 4-5% for soil organic matter in arable soils (MAFF 2000a). Reduced soil organic matter results in decreased capacity for retaining water and nutrients, a fall in number and diversity of soil biota, structural decline and reduced resilience to compaction and erosion.

Erosion is a natural geological phenomenon but some human activities dramatically increase erosion rates. Water erosion on arable land in lowland UK has increased over the last 20 years and it is generally accepted that this is a result of an increase in winter cereals, which are drilled in the autumn leaving the surface soil exposed to erosive autumn rain (Boardman 1990; Evans 1990a,b; RCEP 1996; Boardman 2002; Boardman et al. 2003a,b). Other contributory factors include very fine seed beds produced by modern drill cultivators, arable farming on steep slopes, inappropriate crops such as maize, removal of field boundaries, working land up and down the line of maximum slope, and rolling of seed beds (Boardman 1990; Evans 1990a,b; Skinner et al. 1997; Chambers et al. 2000). Increases in silage maize and outdoor pigs particularly on unsuitable sites in higher rainfall areas are also contributory factors to increased water erosion (Unwin 2001). A large proportion of arable England (36%) has been classified as moderate to high risk of erosion including

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[7] Plough pans result from compaction and smearing at the furrow bottom, these adversely affect rooting penetration.

[8] Slaking is the breaking up of aggregates in the plough layer of arable soils due to wet conditions. Water movement becomes slow and soils become puddled (sandy and silty soils are particularly prone to this). Capping occurs when rain falling on a fine unstable soil surface destroys aggregates and causes a cap to form.

much of the better drained and more easily worked land, especially sandy soils (Skinner and Chambers 1996)[9]. Localised severe erosion events have been reported in the more vulnerable areas, for example, rates of erosion equivalent to 5000 t/sq km were recorded in the West Midlands following a storm event (Foster et al. 1997) while Boardman (1988; 1996) recorded the highest ever erosion rate in arable land in UK on the South Downs following a severe storm event. More intensive rainstorms associated with climate change provide increased opportunities for such events. However, insidious but continuous soil wash can be equally damaging. Wind erosion, although more localised, is a common problem in sandy and lowland peaty soils in the east of England. Farmers themselves recognise that erosion is a problem, with the DEFRA Farm Practices Survey (DEFRA 2002c) reporting that two thirds of farms had experienced at least one indicator of soil erosion at some time with the more extreme forms of erosion occurring on lighter soils on specialist cropping farms.

Erosion adversely affects all soil functions, is generally irreversible and can have serious long-term consequences. On-site the fine sediments and organic matter are lost from the soil when erosion takes place. Off-site impacts of erosion cause diffuse pollution where fine sediments cause water turbidity and impair stream and river ecology, in particular by silting up trout and salmon spawning grounds. Phosphates, pesticides and other contaminants adhere to eroded soil particles and are washed into waterways causing further problems, notably eutrophication (RCEP 1996; DEFRA 2002e, 2003d, 2004c; Environment Agency 2004b).

Localised compaction from livestock also leaves some pasture ground vulnerable to erosion. This can be a lowland feature, where tracks, feeding areas and riverbanks become compacted and eroded, and an upland feature where overgrazing can also cause water erosion adversely affecting landscape, grazing capacity and plant communities. Increases in sheep numbers (about threefold from the 1940s to the early 1990s in the Peak District and Wales) have resulted in overgrazing (RCEP 1996) while drainage by open ditches, careless afforestation, moorland burning and

[9] In general terms the most vulnerable lowland soils have been identified as: Lower Greensand soils of southern England and Isle of Wight; sandy and loamy soils of Nottinghamshire, West Midlands, Somerset, Dorset, and parts of E. Anglia; and chalky soils of South Downs, Cambridgeshire, Yorkshire, Lincolnshire Wolds, Hampshire and Wiltshire (Boardman 1990).

recreation all exacerbate the problem. Peat moors are particularly vulnerable and in some areas are extensively gullied (National Trust 1996, 2002; RCEP 1996). Peat erosion not only affects habitats and plant communities but is also regarded as ecologically and aesthetically unacceptable.

Poor soil management can lead to nutrient enrichment of waterways. Inappropriate fertiliser, pesticide and farm waste management is responsible for the eutrophication, acidification and contamination of surface waters and contamination of groundwater by nitrate, phosphate and biocides. Nitrate leaching from soil into surface and groundwater is associated with inorganic nitrogen (N) applications in intensive arable systems, although organic N inputs including those from ploughing up of grassland are also significant. Intensification of livestock production has created problems of waste storage and disposal by excessive muck spreading on fields leading to both compaction and run off (MAFF 1999c; DEFRA 2002e, 2003d, 2004c; Environment Agency 2004b).

Agricultural use of soil can also reduce soil biodiversity. Mechanical cultivation is highly destructive of soil invertebrates, while agrochemicals reduce genetic diversity of soil microorganisms. Heavy metal inputs in long-term sludge applications decrease microbial biomass and affect grassland species composition (Brooks and McGrath 1984; McGrath 1994). Long-term use of certain fertilisers can also result in soil acidification, which in turn affects soil biodiversity by changing the composition of the flora and fauna. The functional significance of loss of diversity is as yet unknown, although research has shown some detrimental effects (Dighton and Jones 1994; Moore et al. 1995).

Although often described separately, in reality the causes and the outcomes of these threats to soil are typically interlinked. Processes that lead to soil degradation, driven or exacerbated by human activity, are damaging the capacity of soil to continue performing its broad variety of functions and are therefore undermining soil sustainability. There is no evidence of a significant reversal in negative trends and climate change is a further overarching concern for the soil resource.

The CAP continues to underpin many of these threats (JNCC 2002). Agricultural support regimes have encouraged intensive land use, over-looked proper soil management and indeed have exacerbated mismanagement through the promotion of activities such as autumn sowing and fine seed beds. The 1992 and Agenda 2000 reforms reduced support levels and should in principle have reduced intensity. However, although these have gone some way to addressing the negative environmental impacts of the CAP, it is argued that the consequences of past policies persist with the Arable Areas Payment Scheme (AAPS) having effectively frozen the amount of land under arable cropping, therefore restricting opportunities to retire vulnerable soils from production (Winter and Gaskell 1998; Winter 2000; JNCC 2002). The background to these changes has been a continuous trend of falling net farm incomes forcing farmers to improve their efficiency of production. Greater financial pressures on farmers has led to specialisation with increased inputs, changes in cultivation practices and increases in average farm size with greater intensification on some units. For example, the extent of arable land has increased, at the expense of grassland, as has the extent of winter sown cereal (DETR 1998a), all of which continues to have negative repercussions for soil management. A further concern is that lower farm incomes cause farms to cut back on labour which is often essential to comply with environmental requirements (NFU 1995).

Arguably these conditions will continue as farmers enter the harsh reality of market place conditions following the CAP reforms in 2005. The intention of the agreement to reform the CAP is to sever the link between farm subsidies and production and use cross compliance requirements and support for environmental and rural development programmes to alleviate the damaging impacts on the environment (DEFRA 2004b). However, as farmers are reconnected to their markets they may need to intensify further to compensate for low market prices. It has been suggested, for example, that cereal farmers will favour continuous wheat, which will have obvious detrimental consequences for soil. Others consider that greater use of contractors will lead to increased siltation levels (Silcock et al. 2004). Conversely, if cereal cropping becomes unprofitable on more vulnerable land, this land might be retired from production with consequent benefits to soil (Dwyer and Buller 2004; Silcock et al. 2004).

2.3 Soils and sustainability

Increasing recognition of evidence of the various threats to soil has stimulated debate about the need for soil protection through sustainable soil use and management. However, along with this goes a level of ignorance about what constitutes good soil management as well as debate and misunderstanding about what is meant by sustainable soil management. Before reviewing the policy developments in soil protection, this section examines the different understandings, and indicators, of sustainable soil use. It aims to contextualise the issue of sustainable soil use within the wider debate on agricultural sustainability, and to expose the conflicts that exist within the agricultural community about the need for sustainable soil use.

2.3.1 Different understandings of the sustainability concept in the context of soil

Precise definitions of sustainable soil use are elusive and interpreting sustainable use in practice is problematic. The wider literature on sustainability and sustainable agriculture reveals the same uncertainties. Despite an extensive debate exploring the nature and meaning of sustainability it remains an imprecise concept and its definitions and the conditions under which sustainable agriculture occurs are subject to many different interpretations and assumptions. Indeed, some consider that for such a complex and contested concept as sustainable agriculture, a precise and absolute definition is impossible (Pretty 1995).

Soil sustainability cannot be separated from the sustainability of terrestrial ecosystems as a whole nor from the activity of humans. As Gordon et al. (1996) point out, to use the word sustainable to describe the state of any particular resource is a misapplication because the idea is fundamentally about human behaviour. So, taking sustainability as a human centred concept, soil must be considered in terms of how the soil is used. Given this, soil sustainability is intimately coupled with the functions that we demand from it. It is commonly stated that sustainable soil use should ensure that soils can continue to support their full range of functions, as defined by Blum (1993). Central to this is that the current use of soil should not adversely affect its range of other uses, now or in the future, and that soil use should not therefore exclude or constrain other potential uses. However, as Usher (1996) observes we need to ask whether we can realistically demand that *all* soil functions are sustainable, and if so, over what time scale and using what criteria. Interpretations of sustainable use of soil do tend, however, to focus on sustaining a particular function, for example, sustainability under agricultural use depends on maintenance of soil chemical, physical and biological fertility, while sustainable use from a natural heritage view point depends on the soils capacity to sustain its ecological and cultural functions (Gordon et al. 1996). Conversely those involved in water quality protection would look to sustaining the filtering and buffering soil functions. These different emphases can lead to conflicting objectives and definitions for soil sustainability, for example, in agriculture there is a division between policy makers who wish to sustain environmental protection functions of soil, the new thrust of agricultural policy, and those in the agricultural industry who wish to sustain soil productivity functions. These tensions appear in wider debates about what constitutes sustainable agriculture in UK and Cobb et al. (1999a) attribute this to a disagreement over the purpose of a rural and agricultural policy generally with a division between the environment and socio-economic justification for agricultural support. This reflects the conflicts and consequent trade offs required between the three different strands of sustainable agriculture: social, environmental and economic, as identified by a number of commentators (Cobb et al. 1999a; Legg 2000) and demonstrated in Legg's (2000:1) definition 'in a dynamic perspective sustainable agricultural development means that the stock and mix of physical, human, natural and social capital resources can meet increasing and diverse demands on the agricultural sector in the future' and that these 'demands for outputs – food, fibre and other services – are met from farming practices that are economically efficient, environmentally friendly and socially acceptable'.

Arguably, where intensive agricultural practices in England adversely affect soil function, and where future generations will not inherit the soil capital that is currently enjoyed, soil use can be described as unsustainable. Despite the evidence of threats to the soil, as reviewed in section 2.2, it is implicitly assumed in some quarters that the absence of any great soil catastrophe in the UK in recent generations must mean that we are already adopting a sustainable approach to soil use, and this has been the official view within the government and that of the majority in the farming industry (National Farmers' Union (NFU) 1994; DETR 1997; Royal Agricultural Society of England (RASE) 1999). Some scientists, although accepting the evidence about degradation, also question the actual extent of this and whether results should be extrapolated to make general statements about soil use in the UK (Bullock 1987). According to some commentators, the common view expressed by farmers and their technical advisers is that soil is in 'good heart' (Ward 1995). Indeed those in the farming community tend to argue that agriculture is sustainable in UK, that agricultural activities are synonymous with stewardship and conservation of the resources on which they depend. The very fact that they are farming the land is considered by many farmers to constitute protection of the countryside resources (Ward et al. 1990). Farmers themselves have their own notion of sustainability and stewardship, Ward (1995) for instance, suggested that a central idea of family farming ethos has been to pass land onto the next generation in sound working order, implicit in this is a responsibility to the soil. For many farmers and land managers the official jargon of sustainable agriculture remains an unclear and contested concept, or as Country Landowners Association (CLA) (1995:54) state it is 'seen as smokescreen for negative regulation of land use'.

2.3.2 Principles by which sustainable soil use is judged

The question as to whether soil is renewable, substitutable or replaceable and therefore able to recover from degradation has concerned many commentators considering its sustainable use. Although on a geological timescale most soils are renewable, they are not renewable within the timespan needed for regeneration[10], they therefore generally tend to be regarded as non-renewable resources by policy makers (EAA 2000a; MAFF 2000a; Commission of the European Communities (CEC) 2002). A similar concept is that of resilience[11], this is taken as the capacity of soil to withstand environment and human induced shock, although is not well defined or understood (EAA 2000a). In terms of sustainable use, academics have

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[10] Soils have very slow rates of formation so any soil loss of more than 1t/ha/yr can be considered irreversible within a 50-100 year time span (EEA 1999a). Certain soils like peat would be deemed non-renewable because of special conditions of formation.

[11] Resilience may depend on diversity and adaptability of microorganism communities but there is ignorance on levels of diversity required for resilience. It is suggested that the soils resilience is perhaps its worst enemy as its buffering capacity, resilience and capability to filter and absorb contaminants often means damages are not perceived until far advanced (EAA 2000).

used similar concepts to try and evaluate the sustainability of farming systems and the soils natural capital. In O'Riordan's (1993) categorisation of the sustainability of farming types[12], soils are seen as substitutable in 'very weak sustainability' farming systems, but as a non-renewable resource and part of the critical natural capital in 'strong sustainability' farming systems. The concept of 'natural capital'[13] has also been applied to evaluating sustainable agriculture with the 'critical' segment of natural capital of particular relevance to soil (Pearce et al. 1989; Cobb et al. 1999a). Some attempts to address issues of natural capital, the cost of its maintenance and valuation of environmental services flowing from land use have been made on a macro-scale with calculations of the cost of soil erosion (Faeth 1993; Whitby and Adger 1996) and of earthworms (Bailey et al. 1999). Despite these calculations it is argued that the state of science is ill suited to generating the reliable and uncontentious data needed to determine criticality, substitutability, or value estimates for natural resources (Cobb et al. 1999a).

2.3.3 Indicators of sustainable soil use

A further reason for lack of consensus as to whether soil use in agriculture is sustainable is the absence of any agreed parameters for specifically measuring sustainable soil use. There is no absolute standard established for the assessment of soil and attempts to derive a single quality parameter for soils have their limitations (Howard and Hornung 1989; Walter et al. 1997). The site-specific nature of 'soil quality' is not easily interpreted into measurable parameters, and it is less clear how

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[12] O'Riordan's (1993) categorisation of sustainability of farming types was based on three levels of sustainability (very weak sustainability', 'strong sustainability' and 'very strong sustainability') where the key differences result from how the inventory of capital assets are perceived given that sustainability implies the total stock remains constant. Soil is viewed differently in the two extremes; 'very weak sustainability' farming systems are where profits generated are enough to cover the total cost of managing production including cost of maintaining soil productivity by importing fertility (the basis of conventional agriculture). However, in 'strong sustainability' farming systems soil is not to be mined for current productivity if this compromises future soil quality for farming (O'Riordan 1993; Cobb et al. 1999a).

[13] Defined by Pearce et al. (1989:181) natural capital are 'natural resources such as soil and soil quality, ground and surface waters and their quality, land biomass and water biomass, and the waste assimilation capacity of the receiving environment'. Certain elements should not be depleted or degraded because they are the basis of life support, they are not substitutable by other capital assets so their damage is irreversible. This segment of natural capital is called 'critical' and the application of 'criticality' must consider disruption of non-replaceable ecosystems support services such as soil conservation, hydrological cycling that maintain agricultural productivity and thus human carrying capacity (Cobb et al. 1999a).

the concept of soil quality can be translated into farming practices, policy and regulatory statutes. Soil quality is normally described using measurable physical, chemical and biological attributes (texture, pH, nutrient status, structure, soil organic matter) but it is only in relation to a particular end use or natural function that quality can be judged, as every soil's value depends on its user's goals, perspectives and concerns.

Conventionally in agriculture quality is synonymous with fertility which depends on nutrient content and supply to plants, organic mater content, biological activity and soil structural attributes such as porosity, density, water holding capacity, aggregate strength and friability. However, taking a wider view, the concept of 'soil health' is often used synonymously with soil quality (Doran and Safley 1997) but with reference to the soil biological component[14]. However, there is a profound lack of knowledge about of what constitutes soil heath due to our limited understanding of microbial diversity and processes (Moore et al. 1995; RCEP 1996). This lack of information has led some to interpret that there is no problem as the NFU have stated (1994:1) 'as far as soil condition is concerned, we are unaware of any substantive body of research which illustrates that soil quality in UK is deteriorating'.

Despite the difficulties in quantifying soil quality, some conclude that enough is known about soil and that soil standards exist which allow the identification of endangered sites and the implementation of sustainable policies and measures (Auerswald and Kutilek 1998). Certain soil attributes such as soil organic matter have been taken as indicators of trends in soil quality. From this perspective soil indicators of sustainable agriculture have been proposed (Organisation for Economic Co-operation and Development (OECD) 1997; MAFF 2000a; Doran 2001). It is considered, however, that the scientists' heavy reliance on scientific considerations for determining requirements to meet sustainable agriculture for policy makers through the use of indicators is problematic because of remaining knowledge gaps (Cobb et al. 1999a). Nor do they do not give a comprehensive picture of all soil

[14] Neeteson (1995) states that a soil can only be considered 'healthy' if all the groups of soil organisms – the soil food web – function well and are able to play a role in the decomposition of materials, building stable aggregates and pores, preventing and controlling diseases and transforming toxic substances. Cobb et al. (1999b: 209) expands this idea defining soil health as 'the continued capacity of soil to function as a vital living system.... to sustain biological productivity, promote the quality of air and water and to maintain plant, animal and human health'.

issues, part of the problem being the relatively poor bank of good quality, national information about soil, coupled with an incomplete understanding of soil processes. In recognition of this a review of the Representative Soil Sampling Scheme, which has been used to monitor the pH and nutrient status of agriculture soils in England and Wales since 1969, has been commissioned in order to determine its value and its future. The recent *State of Soils in England and Wales* report (Environment Agency 2004b) represents another attempt to formalise and standardise data into measurable indicators for assessing sustainable use.

Although there is acknowledgement that threats to the soil resource exist, developments in soil protection policy have been set against this background of contested understandings of sustainable soil use and lack of information on which to develop indicators. It is to this protection policy that the discussion now turns.

2.4 Addressing the threats to soil through soil protection policy

Despite the increasing threats to soil in UK reviewed in section 2.2 and the critical importance of the soil resource to sustainable agriculture discussed in 2.3, soil protection[15] through policy measures has been slow to develop in the UK compared to some European countries (RCEP 1996). Policy developments within the international, European and UK spheres are reviewed below.

2.4.1 International and European soil policies

The Food and Agriculture Organisation, of which the UK is a member, adopted a World Soil Charter in 1981, which set out the principles for soil resource use and protection and called on governments and international organisations to commit themselves to programmes of soil conservation and reclamation. This charter, together with the World Soils Policy (United Nations Environment Programme

[15] The terms soil protection and soil conservation are often used synonymously. The latter has traditionally been associated with physical measures and barriers to prevent soil erosion as experienced in USA and developing countries while soil protection is the term used to describe the policy actions. However, recently the term soil conservation has broadened to encompass conservation of all soil functions, and the two terms are used interchangeably.

(UNEP) 1982), sought to encourage international co-operation in the rational use of soil resources. Lack of legal obligation to co-operate, however, has meant that these two international agreements have had no impact in the UK. Following the Rio Earth Summit in 1992, the UK signed up to certain international commitments which relate to soil use; including the UN Framework Convention on Climate Change, which requires making provision for carbon sequestration in soils, and the Biodiversity Convention which requires the protection of soil populations at risk.

Although the European Soil Charter was adopted by the Council of Europe Committee of Ministers in 1972 and recognised soil as a vital limited resource (Council of Europe 1972, 1992), there is no comprehensive and specific policy instrument for soil protection at European Union level which legally binds Member states to effective action. The key policy influences on soil use within Europe remain environmental legislation, and the Common Agricultural Policy.

Increasing concern about the extent of degradation in Europe, with evidence of soil loss and declining fertility threatening sustainable development and the viability of agricultural land has led many to call for a European soil protection policy (Blum 1990; EAA 1995, 2000b; van Lynden 1995; CEC 2001). These concerns together with initiatives such as the European Society for Soil Conservation (Auerswald and Kutilek 1998) and the European Soil Forum (ESF) in 1999 have all culminated in the European Commission publishing a communication *Towards a Thematic Strategy for Soil Protection* which was adopted by the European Parliament in 2003 (CEC 2002). This outlines the first steps in a strategy to protect soils, one of seven 'thematic strategies' foreseen under the EU's 6th Environment Action Programme. Commenting on the launch of the publication, Environment Commissioner Margot Wallstrom said: 'We are now placing soil protection on a level with cleaning up our water and air. For too long, we have taken soil for granted. However, soil erosion, the decline in soil quality and the sealing of soil are major problems across the EU. This is a sustainability issue given that these trends are largely irreversible and that soil is vital for our livelihood.' (European Union 2003). A stakeholder group including UK partners is currently working on the issues of policy and delivery.

Although the CAP is associated with threats to soils some protection is offered by the agri-environmental measures in which payments are given to farmers 'who engage in farming practices compatible with the increasing need to protect and improve the environment, natural resources, soil and genetic diversity' (European Commission 2001). Implemented in England as part of the England Rural Development Plan, agri-environment schemes such as Environmentally Sensitive Areas (ESAs) and Countryside Stewardship Schemes (CSS) build on those introduced as accompanying measures under the 1992 CAP reform (EC Reg 2078/92). None of these schemes directly protects soil but it is argued that by removing the more marginal land and more vulnerable soil from less intensive production soils are indirectly protected (Unwin 2001). Boardman et al. (2003a), for example, suggest that expansion of ESA on South Downs could reduce erosion by removing from production the soils most at risk, while other commentators consider that agri-environmental schemes hold considerable promise to prevent and mitigate erosion (van der Born et al. 2000). The new Entry Level and Higher Level agri-environment Schemes and the Whole Farm Approach hold some potential to tackle problems such as diffuse pollution and encourage farmers to identify areas of soil risk and establish buffer strips if necessary, while the introduction of the requirements for a farm Soil Management Plan within the GAEC represent the most significant recent development in European policy in terms of soil protection (DEFRA 2004b).

2.4.2 UK policies that indirectly affect soil use

There is no explicit soil protection policy in the UK although many UK policies responding to international commitments and European policy and regulations do provide implicit protection through promoting sustainable development, in particular in agriculture, and by legislating on the environment through controls on activities that have an impact on air and water.

Recognising that soil has a critical role to play in environment, economic and social sustainability the government regard the sustainable use of soils as a step towards the wider objective of sustainable development (DoE 1994; DETR 1999; DEFRA 2002a). The publication *Towards Sustainable Agriculture: A Pilot Set of Indicators*

(MAFF 2000a) suggests several soil and farming system indicators to determine whether agriculture in the UK is sustainable (Appendix 1). The government recognises that soils need to be protected from long-term degradation that could compromise the viability of competitive UK agriculture. For example, the farming and food strategy for England *Facing the Future* (DEFRA 2002a) sets out principles which stress sustainable land management within the biological limits of natural resources and recognise the detrimental effects of agriculture on the environment.

Legislation relating to soil use in agriculture primarily concerns its role as a buffer and filter for pollutants in water. Statutory laws and regulations that relate to soil use are listed in Appendix 1, many UK regulations implement EU directives. Those likely to have most impact on soil management practices are the recent designation of 55% of England's land area as NVZs (Nitrate Vulnerable Zones) in accordance with 1991 EU Nitrates from Agricultural Sources Directive which sets compulsory limits on farmer fertiliser and manure practices; and the implementation of the EU Water Framework Directive which emphasises the control of diffuse pollution. The importance DEFRA is according these issues is clear from the number of reviews undertaken and the recent consultation document published (DEFRA 2004d,e). The EU Environmental Impact Assessment (EIA) Directive, which controls changes in use of uncultivated land, offers some protection to undisturbed soils. Soil is excluded from the responsibilities of the conservation agencies under the Countryside Act 1968 and the Wildlife and Countryside Act of 1981, although indirect protection is offered through habitat protection; while planning law affords some protection of the most 'best and versatile agricultural land' from development.

2.4.3 Specific soil policy development in England

Early interest in soil protection embodied the dominant concern for protecting productive agricultural soil, as reflected in the identification of 'best and most versatile agricultural land' under the Agricultural Land Classification. The *Strutt Report* (MAFF 1970), undertaken by the Agricultural Advisory Council for MAFF, was the first review of the effects of agricultural practices on soil fertility and structure (as discussed in section 2.2). Following this the DoE commissioned a report to assess factors which ought to be taken into account in formulation of soil protection policies (Howard and Hornung 1989). However, it was not until the publication of the Royal Commission for Environmental Pollution's Report *Sustainable Use of Soil* (RCEP 1996) that interest in soil protection emerged again. The report called for 'a firm commitment by central government and their sectors to use soils only in ways that are sustainable' RCEP 1996: 170); it recommended the implementation of a soil protection policy for UK with conservation of agricultural soils a central component. Evidence and submissions to the commission were provided by a range of bodies, reflecting in part the multifunctional nature of soil (Countryside Council for Wales (CCW) et al. 1994; NERC 1994; NFU 1994).

As other European countries have embraced soil protection policies, for example, the Netherlands and Germany, the pressure for the UK to address this policy gap has increased. Calls for a policy which protects soil have grown from individuals (Boardman 1988, 1990, 2002; Thompson and Bullock 1994) as well as organisations such as the British Society of Soil Science (BSSS); Friends of the Earth (FoE 1996), CPRE, the National Trust, the Soil Association, Scottish Natural Heritage and the Environment Agency, many of whom have independently developed their own literature, soil protection policies and charters (National Trust 1996; BSSS 1997; Scottish Natural Heritage 1997; CPRE 1994, 1998a,b; Environment Agency 2004b). Pressure for change has also come from consumers demanding that food is produced without excessive artificial inputs and without unnecessary harm to the environment, as reflected in growth of the organic food movement and farm assurance schemes. Issues such as nitrates leaching from agricultural land into drinking waters and flooding exacerbated by sediment run off from arable fields have also engaged public and commercial interest.

In response to these concerns and to the RCEP report the government published *A Draft Soil Strategy for England – a Consultation Paper* (DETR 2001). This strategy promotes the sustainable use of soils specifically in England by integrating existing policies and legislation; it aims to:

- manage the extent of our soil resource in ways which ensure we can meet our present and future land use needs;

- manage the diversity of soils concentrating particularly on our most valued soils so that the right balance of soil type is available to meet current and future needs for soil to support our ecosystems, landscape, agriculture and cultural functions; and
- maintain and improve the quality of our soils at a level where soil function is not impaired to ensure we can meet our current and future soils, environment and economic needs.

This proposed strategy is, however, not without its critics as the responses to the consultation demonstrate (DEFRA 2003c). Of the 110 separate responses some see a strategy rather than a policy as insufficient, and demand explicit soil protection measures to reverse soil degradation trends; they note that no single government department has or recognises lead responsibility for protecting soil resources; and that the strategy relies heavily on voluntary compliance with the Soil Code (MAFF 1998b) which to date has proved ineffective (Coi 1996). Some argue that the focus is still on production-oriented issues and see this is as a major obstacle to the improvement of soil protection as a wider issue, as noted by Thompson (1992). That the Soil Code is restricted to farmed soils is seen as a prime example of this single-minded approach. Others consider that the strategy is too focused on environmental aspects and neglects the wider role soil plays in the economy and social capital by sustaining tourism and amenity. Natural heritage organisations have criticised the document as neglecting the full range of soil functions, for example, the protection of soils and their ecosystems in their own right. Many responses acknowledged that demands on soils are increasingly conflicting and could undermine the achievement of sustainability objectives. The government accepts that the strategy, although well regarded for its description of key threats to soils, does not identify specific objective actions. To this end the *First Soil Action Plan for England* (DEFRA 2004a) has been developed by key NGOs, academics and other government departments and agencies to address these concerns and to set out the actions to be taken to achieve the strategy's objectives. The coincident publication of the Environment Agency's consultation on its own *Strategy for Soil Protection, Management and Restoration* (Environment Agency 2004a) and identification of soil as a priority area for action in the new *Rural Strategy* (DEFRA 2004f) indicates further efforts from the policy community to address the threats to soil within England.

The emergence of soil protection strategies both in England and in Europe demonstrates the increasing importance that soil is being accorded in terms of protecting all its functions, and in particular in underpinning sustainability objectives. However, the fact remains that there is no soil protection policy in England, instead the draft Strategy and Action Plan rely on integrating the different strands of policy from other sectors.

2.5 Sustainable soil management: research priorities and responsibilities

The policies and legislation outlined above have provided a backdrop for government funded soil research in the UK (Soil Science Advisory Committee 1998; ADAS 2000c; MAFF 2000b; Drew Associates 2003; DEFRA 2003b). However, as a recent Audit of UK Soil Research states 'few of the policy questions are soil specific – policy questions have a soil component as part of a bigger, often environmental driver' (Drew Associates 2003:1). This is reflected in the wide ranging research programmes and outputs described in this and the following section. This section provides an overview of the main funding and contracting bodies concerned with soil research in UK and describes the research priorities that relate to sustainable soil management. Understanding this research base will help to contextualise the more detailed analysis of the soil management practices derived from research and discussed in the next section.

The Research Council (BBSRC and NERC) funded programmes make the main contribution to scientific progress through basic oriented research with Rothamsted Research and IGER playing a central role. Meanwhile DEFRA is the main government department funding strategic research on soil which is carried out by a range of contractors, prominently Rothamsted Research[16], Institute of Grassland and Environmental Research (IGER), NSRI (National Soil Resources Institute), ADAS and Universities. In addition strategic research and experimental development targeted directly at improving commercial practices is carried out by agrochemical

[16] Formerly called Institute of Arable Crops Research (IACR). Rothamsted Research was created by the merger of Rothamsted, Long Ashton and Brooms Barn research stations.

and fertiliser companies and the Levy Boards. Farmer funded research organisations such as The Arable Group (TAG, formerly Arable Research Centre and Morley Research Centre) also conduct some research relevant to soil management directly in response to farmers' needs.

Research funded by DEFRA underpins environmental protection legislation and policies for sustainable agriculture. DEFRA's research policy aims with respect to soil and land use are twofold: firstly to provide a sound scientific base to ensure its policies protect the environment and as part of this do not submit soil to long-term irreversible degradation or loss; and secondly to enhance the sustainability and competitiveness of the arable industry through use of sustainable production techniques (MAFF 1996; DEFRA 2003b). These reflect the economic and environmental aims of sustainable agriculture policies[17].

Mitigation of nutrient pollution from agriculture and soil protection are central to DEFRA's environmental protection research programme. The soil protection programme has focused specifically on agricultural practices that maintain and enhance soil fertility and do not irreversibly deplete soil quality and its productive capacity and in particular aims to provide a sound scientific basis for up dating the Soil Code (MAFF 1998b)[18].

In terms of enhancing arable production DEFRA's Arable Crops and Horticulture research programmes (with an estimated budget of 6566k for 2000/01) are emphasising efficient but environment friendly farming through appropriate crop management, nutrition and soil ecosystem research in cereals, setaside and in organic farming (Home Grown Cereals Association (HGCA) 2000; DEFRA and HGCA 2002). Increasingly DEFRA's research is in collaboration with HGCA and industry. For example, the LINK programme is a collaborative scheme in which DEFRA

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[17] The most recent strategy *DEFRA Our Strategy 2003-2006 Science and Innovation Strategy* (DEFRA 2003b) lays out plans for the science needed to underpin and provide evidence for DEFRA's policy programme for 2003-6. It emphasises the cross cutting nature of its two themes pertinent to soil, Conservation and Use of Natural Resources and Sustainable Food and Farming. They will receive respectively 9% and 34% of the 155m R&D budget for 2003-4.

[18] The expenditure of MAFF's Soil Protection Programme was £1015k for 1997-1998 (MAFF 1998c) while spending on emissions from agriculture research was £10.4m, from a total spend of £121m (Agricultural Food and Fisheries Research Funders Group 1999).

funds up to 50% of research costs; LINK projects have provided funding for research within the Technologies for Sustainable Farming Systems theme which include IFS (Integrated Farming Systems); SAPPIO (Sustainable Agricultural Production through Precision and Input Optimization); SAFFIE (Sustainable Arable Farming for Improved Environment). However, recent estimates of the allocation of soil research funds found only about a quarter of soil research programmes aimed at producing practical outcomes, with just over half of these being food/biomass production programmes funded by government departments or Levy Boards. The remainder were air/water quality and soil protection related (Drew Associates 2003); clearly this is where the priority is for soil research.

This review has shown that a large number of organisations have responsibility for funding and implementing a range of research programmes and projects which are relevant to sustainable soil management. It is to the outputs from this research that the discussion now turns.

2.6 Sustainable soil management: research outputs and dissemination

The research programmes described above support a diverse and numerous array of projects researching into soil in relation to environmental protection and sustainable agriculture, as the Register of Agri-Environmental R&D 1999/2000 (MAFF 2001a) demonstrates. An overview of these initiatives, as they relate to sustainable soil management policy objectives, is provided here to demonstrate the diversity and complexity of research outputs concerning soil management that the advisory community are increasingly being asked to engage with and deliver to the farming community.

Dissemination or knowledge transfer (KT)[19] of the results from these research projects to the practical farming community has become an important component of DEFRA's policy implementation on sustainable use of soil and environmental

[19] Refer to footnote 4

protection. Results from DEFRA funded projects are synthesised and disseminated in the form of written guides, such as the Soil Code, or decision tools. For example, the MAFF Nitrate Programme has considerably improved understanding of soil nitrogen cycling, and a range of nitrate reduction strategies have been developed and disseminated (Dampney et al. 2000) including: improved economically-based advice on fertiliser N inputs to arable and grass crops in the form of *RB209 Fertiliser Recommendations for Arable and Horticultural Crops* (MAFF 2000d); information on the N value of livestock manures as affected by timing and method of application in the form of *Managing Livestock Manure* booklets (ADAS 2000a); and Decision Support Systems or tools such as the MANNER (MANure Nitrogen Evaluation Routine) PC decision tool. These all provide guidance on best management practice for soil for advisers and farmers (listed in Table 2.1). This list will expanded in summer 2004 with the publication of new DEFRA guidelines on the principles of good soil management (compiled by ADAS and NSRI) to accompany the introduction of GAEC (DEFRA 2004b; Farmers Weekly 2004a,b). Dissemination to scientific users continues in the form of scientific publications, while for scientific users and practitioners the DEFRA *Agriculture and Environment R&D Newsletter* provides a general update of projects and outputs. DEFRA also contract ADAS to run an extensive programme of campaigns to introduce products such as MANNER and RB209 to the practical community and these involve press articles, roadshows, workshops, seminars and training.

Other organisations are equally active in disseminating literature and providing training or workshops relevant to soil management based on research results. The Environment Agency, like DEFRA, emphasises environmental protection in its publications. Other commercial, farmer-funded organisations and NGOs, however, focus their efforts on soil management in the context of commercial agronomy. The Levy Boards and TAG publish research reviews, newsletters and topic sheets, maintain an informative website, hold field days and run training courses while commercial organisations have started to produce glossy leaflets which concern soil management in relation to cultivation. Table 2.2 lists recent contributions from non-DEFRA sources.

Table 2.1 Research outputs on soil management disseminated from DEFRA research sources.

Research Output	Details
Code of Good Agricultural Practice for the Protection of Soil (the Soil Code)	Revised and updated in 1998 according to recent research evidence, the Code is a compilation of legislation and guidance developed as a reference guide and delivered to all farmers. Now a requirement for Farm Assurance Schemes and some agri-environment schemes
Integrated Farming: A Report from the IACPA for Farmers, Agronomists and Advisers	Synthesis of integrated farming research from Integrated Arable Crop Production Alliance (IACPA) project sites. Sponsored by MAFF
Managing Livestock Manures Series of 3 booklets • *Making better use of livestock manures on arable land* • *Making better use of livestock manures on grassland* • *Spreading systems for slurries and solid manures* MANNER (MANure Nitrogen Evaluation Routine)	MAFF funded research on nitrates synthesised from research programmes at ADAS, IGER and IACR over 10 years (MAFF 1999c) Summarised in *Soil Use and Management* 16, Supplement 1 (2000); Powlson 2000 Booklets and MANNER PC programme provide farmers with a quantitative assessment of fertiliser N replacement value of manure applications
Fertiliser Recommendations for Arable and Horticultural Crops, RB209	Revised 2000. Research on nutrient dynamics in soil at IACR and the nitrate programme (Bradbury et al. 1993; MAFF 1999c)
Nitrogen Fertilisation of Field Crops: an update	Research synthesised from the nitrate programme
Controlling Soil Erosion by Water • *A manual for the assessment of agricultural land at risk of water erosion on lowland* • *A field guide for an erosion risk assessment for farmers and consultants*	Five class risk assessment based on a monitoring survey exercise ((MAFF 1999a,b; Skinner and Chambers 1996; Chambers et al. 2000)
Agriknowledge: Helping Farmers Back to Profit.	Compilation of articles published in *Crops Magazine* Agriknowledge initiative in 2001 (DEFRA and HGCA funded)

Clearly advisers are faced with a large collection of events, publications and tools emphasising different aspects of soil management. Dissemination of these research outputs represents the DEFRA's key mechanism for delivering their sustainable soil management policy objectives to the farm.

Table 2.2 Research outputs on soil management disseminated from non-DEFRA research sources.

Research output	Organisation conducting research
Arable Cropping and the Environment - a Guide	DEFRA and HGCA
The Establishment Business	Vaderstad
Improved Soil Management for Agronomic and Environmental Gain	Soil Management Initiative
• *Best Farming Practices: Profiting from a Good Environment* R&D Publication 23 • *Diffuse Pollution from Agriculture A Field guide* R&D Publication 13 • *Understanding Buffer Strip: an information booklet*	Environment Agency
Conservation Agriculture: A Decision Making Guide to Reduced Tillage Systems	Monsanto
Conservation Agriculture in Europe: Environmental, Economic and EU policy Perspectives	European Conservation Agriculture Federation
Sustainable Soil Management – an Achievable Goal	European Fertilizer Manufacturers' Association
A Guide to Better Soil Structure	National Soil Resources Institute
Environmental Management for Agriculture (EMA) software	University of Hertfordshire

2.7 Achieving sustainable soil management on the farm

Translating this considerable body of research and policy development into practice and achieving sustainable soil use on the ground in UK is the challenge for the policy, research, industry, advisory and farming communities. Although some regulations, as within NVZs, are increasingly impinging on soil management decisions, at present there is no single policy or regulation, which dictates what soil management practices should be used on farm. Given this, sustainable soil use will be achieved in large measure through a set of voluntary practices rather than through any specific system or scheme. This section goes on to consider the characteristics of the farming systems and practices that need to be implemented to achieve sustainable soil management in this context.

Just as the concept of sustainable soil management remains little understood, so too does our understanding of the sustainability of different farming systems and application of different technologies. Some argue that sustainable agriculture can only be achieved through adopting alternative farming systems such as organic farming, while others, like the chemical industry, see sustainable agriculture as being simply a technical issue of devising more environmentally friendly chemicals. Another view suggests that 'technologies for sustainable agriculture cover the whole spectrum of farming systems'; that all systems from organic to intensive have potential to be sustainable and that there is no unique system that is sustainable (OECD 2001: 6). In the UK the options for achieving sustainable agriculture range from farm management systems which involve a complete change of approach to using more specific discrete practices. The former include farming systems such as organic farming and its variations 'biological', 'biodynamic' and 'ecological farming'; Integrated Farming Systems (IFS)[20]; and conservation agriculture[21] (ECAF no date), while the latter include specific measures such as reduced tillage, winter covers, use of composts, and barrier or buffer strips incorporated into existing farming systems.

It is thought that very few farmers in UK will satisfy all the requirements of sustainable agriculture at present (O'Riordan 1993). A number of less intensive practices and systems based on the principles of low inputs and resource conservation and recycling do, however, go some way towards meeting criteria for sustainable soil management and provide opportunities for protecting a range of soil functions. Organic farming, for example, operates on the principles of recycling nutrients through manures and crop residues, protecting the soil through rotation and the improvement in soil organic matter content. Generally, although not always, it compares favourably with conventional systems in terms of some soil nutrient parameters and soil physical conditions (Reganold 1995; Cobb et al. 1999b; Sheppard et al. 2000; Clark et al. 1998). Sustaining or improving the soil resource and protecting the environment are also at the heart of IFS. Central to these approaches are the principles of crop rotation to promote soil structure and fertility; minimum cultivation to promote structure and biodiversity and reduce erosion; and

[20] IFS. There are several definitions for integrated farming. One is 'A system of agriculture which is more sustainable for the environment and profitable over the long-term, encourage biodiversity and which produces safe affordable food' (DEFRA and HGCA 2002:4).

[21] Conservation agriculture describes non inversion tillage while reduced tillage can be thought of as shallow tillage. These terms are defined in full in Chapter 4.

reduced and targeted chemicals. The benefits to the soil and the environment of IFS have been extensively documented (Jordon et al. 1997; Hutcheon 1993; Drummond 2000; Jordon et al. 2000 Garcia-Torres et al. 2001; DEFRA and HGCA 2002).

Most farmers in UK, however, are unlikely to change radically, preferring to make only slight alterations to their current practices rather than whole system changes. They are, however, responding to legislation and market pressures and seeking ways to reduce their unit cost of production (Jordan et al. 1997; OECD 2001) as, for example, through the use of reduced cultivation and reduced agrochemical inputs[22].

This suggests that the best hope for sustainable soil management lies in modifying or rationalising existing practices through encouraging 'best management practices'; also called 'good agricultural practice' (GAP), 'best farming practice' (BFP), and 'good farming practice' (GFP). Definitions for best management practice are elusive and those that do exist, for example, the EU's definition of GFP as 'the standard of farming, which a reasonable farmer would follow in the region concerned' are so broad as to be almost meaningless. The practices are normally interpreted as entailing compliance with general mandatory and environmental legislation requirements, for example, only those who go beyond the standards of GFP are eligible for funding for agri-environment schemes in Europe. In the UK GAP entails voluntary compliance with DEFRA's Soil Code (MAFF 1998b), which outlines a range of soil management options available to the farmer. The Environment Agency describe BFP as synonymous with good environmental care of air, water and soils and refer to the practices as 'simple changes' to the way farmers do things, and as practical options which bring cost savings and environmental benefits, describing them as 'win-win' practices. Others similarly stress an economic basis to best management practice, for example, the European Fertilizer Manufacturers Association (EFMA no date: 19) state 'BMP describes the concept of combining soil management practices and other agricultural management practices to arrive at the most effective economic way to avoid soil degradation'. Most recently the proposed introduction of Soil Management Plans which will accompany the 2005 CAP

[22] Results from the DEFRA Farm Practices Survey (DEFRA 2002c) suggest that land mangers are beginning to supplement fertilisers with nutrients from manure. The survey found that 38% of specialist cropping farms and 15% of cattle farms with crops were reported to be using lab analysis to estimate slurry and manure nutrient content.

reforms adds another layer of complexity with more than 70 possible measures proposed, although it may offer precise soil standards against which to measure best management practice (DEFRA 2004b)[23].

Clearly current standards of best management practice are not very demanding on farmers because of difficulties with verification and the lack of standards against which to measure them. Similarly interpretation of what constitutes best practice is difficult as these practices are decision based and site specific in that they are based on recognising and acting on problems and opportunities on the farm at specific times. Distinguishing these practices from conventional practices is not easy, indeed many farmers would argue they are already practising some form of best management practice. Also, although described as a set of discrete practices these practices are generally interlinked and for best effect they should be integrated, or implemented as part of a whole farm approach, and as such they demand a new outlook.

For the purposes of this research the term 'soil best management practice' will refer to 'practices which do not degrade the soil's ability to function in the long-term'. The underlying principles on which soil best management practice are based are: the protection of soil structure and soil organic matter content through carefully timed cultivations and maintenance of surface cover; nutrient budgeting through carefully timed application of manures and fertilisers to meet crop requirements; and stock management to prevent compaction. These principles underpin the publications and tools described in section 2.6 (listed in Tables 2.1 and 2.2).

Best management practices are the basis of the government's policy aims with respect to achieving sustainable agriculture, soil and environmental protection. The promotion of soil best management practices based on principles set out in the Soil Code is central to the proposed *Draft National Soil Strategy* (DETR 2001) and the *First Soil Action Plan for England* (DEFRA 2004a). DEFRA's Food and Farming Strategy (DEFRA 2002a) emphasises the farmers' responsibility in realising

[23] 'Environmentally sensitive farming' promoted under schemes such as ESA and CCS, compliance with requirements for Farm Assurance Schemes and the restrictions of NVZs constitute other routes towards sustainable agriculture. 'Catchment-sensitive farming' proposed in the DEFRA consultation (DEFRA 2004e) to combat diffuse pollution will be based on the same principles as best management practice.

sustainable agriculture and aims to promote the benchmarking and spread of good agricultural practice through demonstration farms while the GAEC, which are integral to cross compliance within the CAP reforms, are underpinned by best practice principles. Best management practices are also used as indicators of sustainable agriculture, for example, adoption of alternative farm management systems; area converted to organic farming, knowledge of the Soil Code and manure management are included in the pilot set of indicators proposed by MAFF (2000a). Clearly the agricultural community cannot ignore these practices which form the central platform for the government's policy on sustainable soil management.

2.8 A role for the adviser community in supporting soil best management practice

2.8.1 New demands on advisers in the Agricultural Knowledge System (AKS) in England

Although soil best management practices are difficult to characterise, one element these practices all share is that they are non-prescriptive and demand attention to detail, local observation and sometimes understanding of scientific principles on which the practices are based for their successful implementation (OECD 2001). This is clear, for example, with the proposed SMPs in England, as DEFRA state 'We do not propose....a prescriptive approach but an individually tailored risk based SMP produced by each farmer. The SMP approach will require farmers to understand and analyse risk on their farm prior to undertaking measures that target a practical problem. It allows farmers some choice selecting measures appropriate to their situation' (DEFRA 2004b: 17)[24]. As such farmers require more information and on-farm advice to support them in their transition to sustainable soil management through the use of soil best management practices, something recognised by policy makers (DEFRA 2004b,e,f). This has already been demonstrated for other knowledge demanding practices such as IFS (Park et al. 1997; Morris and Winter

[24] Similarly DEFRA's proposed 'catchment-sensitive farming' will require farmers to understand pollution pathways and learn new soil management skills to reduce emissions (DEFRA 2004e).

1999), reduced tillage (Tebrugge and Bohrnsen 2001; Coughenour 2003) and organic farming (Burton et al. 1999).

Policy and research priorities to direct and enable sustainable soil management have been outlined above, however, it is the actors who provide advice to farmers who have potentially the most important role in supporting farmers to undertake relevant best management practice for soil. The agricultural advisers' critical role in enabling policy implementation in supporting agronomic practice, promoting conservation, influencing policy implementation, regulating and advising on anti-pollution measures has been highlighted in Chapter 1. Their role in facilitating soil best management practice is considered to be particularly significant given the complexity of the practices, the heterogeneity of farm soils and the individuality and locally specific nature of farm based planning that is needed. In this respect the role of the farm adviser in supporting the proposed SMPs is something which has not escaped the attention of industry commentators (Farmers Weekly 2004a,b). Whilst it cannot be denied that other mechanisms that utilise the farmers' own knowledge and promote farmer learning such as farmer-farmer interaction, demonstration farms and group learning are important (Cerf et al. 2000; Ison and Russell 2000; Roling and Wagemaker 2000), advisers remain essential, particularly given farmers increasing reluctance to share knowledge with their peers, in order to retain a competitive advantage (Angell et al. 1997). It is also argued that the unfamiliarity of many environmental problems and their technical solutions means that farmers are themselves often ill-equipped to deal with them and need specialist inputs from advisers (Vanclay and Lawrence 1995).

Advisers do not, however, operate in isolation and comprise a significant element of what has been labelled the Agricultural Knowledge System (AKS). The influences, structure and organisation of the AKS in England will therefore affect the potential role of advisers in facilitating soil best management practice. Within England, new policy and research priorities in agriculture which emphasise sustainable production and environmental protection rather than productivity, together with farmers' changing requirements for advice in a more competitive and restructured industry, have inevitably impacted the institution of agricultural advice. Pubic extension has had to renegotiate its role with agriculture and in England this led to the privatisation of ADAS in 1997 (Buttel 1991; Coutts 1995; Needham 1998: Rivera 2000). This had significant consequences for agri-environmental advice with the loss of a publicly funded extension service and the coincident emergence of a new, diverse advisory community to fill the gap (Winter 1995; Gasson and Hill 1996; Nilsson and Wallace 1998; Carver 2000; OECD 2000; Winter et al. 2001; Garforth et al. 2003)[25]. The remainder of this section will review these changes and discuss the implications of a diverse advisory community for achieving sustainable soil management specifically in England.

2.8.2 Loss of extension and integration within the Agricultural Knowledge System

Arguably privatisation has left a weak public extension system for supporting the transition to sustainable soil management through best management practice. Others express similar concerns claiming that publicly funded information services have been scaled back at exactly the time when the rationale for delivering advice concerning the provision of public goods seems most strong (NAO 1991; Curry 1997; ECOTEC 2000; Garforth et al. 2003).

As well as changing the way in which ADAS advisers operate, privatisation has impacted on the integration of the AKS as a whole. Before privatisation ADAS combined the functions of research, development and advice, with a well-established communication path whereby ADAS conducted applied research and development for MAFF and disseminated results through free advice. With the change in status of ADAS this chain of communication was severed and vertical fragmentation of the AKS resulted (Winter 1995). With reference to sustainable soil use the RCEP (1996) report noted that the close rapport which previously existed between farmers, advisers and researchers was eroded with the loss of ADAS making dissemination of soil research outputs difficult. The change in status of ADAS meant that DEFRA has struggled to find the mechanisms to connect research on environmental protection and sustainable agriculture to farmers. Evidence of a poor level of awareness of the

[25] Announcement of the establishment of a new Integrated Agency by DEFRA (2004f) as a single independent statutory organisation championing integrated resource management, nature conservation, biodiversity, landscape, access and recreation will lead to restructuring of some elements of the AKS framework in England.

scale and scope of UK soil research amongst a range of potential users confirms that there is a more general pervasive problem in communicating research results to practical users (Drew Associates 2003). DEFRA's Knowledge Transfer strategy is underpinned by a limited programme of free advice together with a range of activities associated with promoting the Soil Code. These combine with dissemination of outputs from DEFRA funded research projects, as described in section 2.6, which commentators claim have been 'bolted on' to research projects (Archer 2001). Archer (2001:5) lamented the lack of coherence and described diversity as the overriding feature of current and recent DEFRA Knowledge Transfer activities in his review observing that 'it is often not apparent why a particular activity was initiated....there are too many examples of initiatives that have started without clear objectives and petered out after an initial burst of enthusiasm'. Poor mechanisms for consultation with users and lack of farmers/land managers representatives on research panels were also highlighted as a problem (Drew Associates 2003)[26]. There is concern that current arrangements for advisory services for land managers are inadequate to the task of ensuring farmers have access to advice that will enable them to make decisions compatible with policy or to meet the challenges and opportunities of a reformed CAP (Cabinet Office 2002)[27].

2.8.3 Proliferation and diversity within the Agricultural Knowledge System

Since ADAS's change of status there has been a proliferation of agri-environmental advice providers from all sectors including trade, NGOs, farmer funded organisations, research institutes etc., who are using a number of mechanisms to deliver a range of messages (Winter 1995; Curry 1997; Archer 2001; Winter et al. 2001; Garforth et al. 2003). The plethora and diversity of advice providers is illustrated by the following comment in a recent review of environmental protection and conservation advice: 'It is clear that there are several hundred organisations,

[26] Proposals in the new *Rural Strategy* (DEFRA 2004f:13) include 'improving the effectiveness of current knowledge transfer arrangements so that the relevant results of commissioned research and development are consistently translated into useful and practical business improvement tools'.

[27] These inadequacies have been recognised by government. Proposals as part of the new *Rural Strategy* (DEFRA 2004f:13) include: 'a new advisory package to support the introduction of the cross-compliance requirements; and targeting publicly funded conservation advice so that it supports implementation of the new entry-level and higher-tier agri-environment schemes; making the supply of learning provision consistently relevant to rural business requirements and improving its delivery'.

including all private sector companies who are part of associations, who have an interest or opportunity to provide environmental protection and conservation management information and advice to farmers' (Dampney et al. 2001: 65).

The privatisation of ADAS led to the expansion of an already growing commercial advice sector and the increase in private agricultural consultants noted prior to privatisation appeared to continue (Eldon 1988; Fearne and Ritson 1989; Dancey 1993; Gasson and Hill 1996; Rivera 1997; Kidd et al. 2000). Some suggest that greater use of private sources of advice was accompanied by a wide cultural shift during the 1980s relating to a changing perception of the competence of the private sector (Ward and Munton 1992). A growing reliance on specialist technical advice is thought to explain the continued growth today in use of independent advisers by farmers (Ward 1995; Tsouvalis et al. 2000a; Garforth et al. 2003). Agrochemical suppliers have similarly developed and expanded their advisory capacity in response to agricultural changes, becoming increasingly science based and environmentally sensitive (Whittemore 1998). The number of advisers within NGOs promoting or becoming involved in conservation and environmentally responsible farming has also expanded, significantly RSPB, National Trust, and LEAF, while contributions from Wildlife Trusts and National Park Authorities (NPA) have also increased (Winter 1995; Winter et al. 2001). Agri-environment scheme advisers working within DEFRA's Rural Development Programme represent another cohort of the adviser community. From this review it is clear that agricultural advisers are not a homogenous group but rather a collection of individuals with very different objectives and means of operating.

One of the concerns about complex and diverse advice provision is the lack of coordination and the resulting duplication and competition among providers, resulting in gaps in provision, information overload, confusion, contradiction and even misinformation to farmers as well as geographically uneven advice (Craig 1995; Winter 1995; Gasson and Hill 1996; Black 2000; Morris et al. 2000; Archer 2001; Dampney et al. 2001; DEFRA 2003a). Winter (1995) refers to this as horizontal fragmentation of the AKS. Some of these issues are evident in the AKS sector that delivers advice concerning soil. Responses to the RCEP (1996) identified poor co-ordination, and the difficulties of multi agency involvement, as holding back soil protection activities leading the report to conclude that government action on soil is 'fragmentary and uncertain'. Given that 'information management is the key ingredient in the development of sustainable farming options' (Oberle 1994:121), this uncoordinated information and advice system would seem poorly equipped to deliver best management practice for soil.

Although there are concerns about the lack of coherence and inadequate lines of communication between the large numbers of actors involved in this more 'open' AKS, it is believed that there are positive outcomes as well (Winter et al. 2001; Garforth et al. 2003). Involvement of many agencies and actors, including an active NGO sector, and interaction between agencies can provide the flexibility and space for creativity, and for networking and alliances which were denied under a more rigid closed system. As Jones and Garforth (1997) state, flexibility and adaptability should be seen as virtues rather than aberrations in the AKS of the future. In addition, a greater number and diversity of actors means that the AKS becomes more information-rich. It is argued that as land managers need different types of information at different times with differing degrees of detail and prescription, diversity of services and means of delivery is a positive feature. With individuality of farmers and their practices, it is considered that a pluralistic array of providers is exactly what is needed (Rivera 2000; Garforth et al. 2003). Whether this is the case for soil management advice needs to be examined within this research.

2.8.4 Skills and knowledge within the adviser community

The diverse advisory community described above will possess a range of skills and competence, some better suited than others to support soil best management practice. Some claim commercial advisers are ill equipped to promote public good messages; that consultancy is not a substitute for extension (Harter and Hass 1992; Gasson and Hill 1996). Meanwhile, others consider that they promote intensification (Eldon 1988) and that they perceive and treat environmental practices as a constraint, rather than an objective of, farming practices. This is related to what some described as a 'structural inertia' in providers due to market orientation of advice services and the heritage of production-oriented advice which is enduring within all advisory services (Winter 1996; Curry 1997). Wilson (2001) takes a similar theme and talks of advisers having 'productivist modes of thinking' arguing that there is a lack of evidence (Cooper 1999, Clark et al. 1997; Lowe et al. 1997) of a shift towards post-productivist thinking amongst what he calls intermediate level actors such as street level bureaucrats and pollution officials. Proponents of this view also claim that commercial advisers' environmental skills are poorly developed (Curry 1997). The implication that commercial sector independent advisers will not give great priority to, nor have knowledge of, good agricultural practice (GAP) and environmental protection matters is borne out by Winter (1995) who found relatively low levels of conservation and environmental expertise amongst BIAC members. Some commentators also suggest that agronomists even struggle to keep up with the demands of technical developments within arable agriculture itself (Bullock and Bullock 2000).

However, more recent research suggests that commercial advisers can play a positive role in facilitating best management practice. Although Marshall's (2002) survey of agronomists' environmental skills reflected different levels of knowledge and experience, it found that some were well advanced and already giving sound environmental advice, including habitat management, fertiliser and FYM use, ICM and whole farm plans, with 51% providing it unprompted. In addition, FACTS[28] certification for advisers, which is widely subscribed to, ensures a certain standard of knowledge of fertiliser (inorganic and organic) application and of the Soil Code, although there are no schemes to develop and maintain professional advice standards in other important technical areas such as conservation management, the design, maintenance and management of manure handling facilities, nor soil management[29].

Conservation advisers traditionally have had a limited input into soil best management practice advice. However, with greater interest developing in protection of aquatic habitats, advisers are increasingly persuading farmers to either change

[28] Fertiliser Advisers Certification and Training Scheme (FACTS) is co-ordinated by BASIS. The scheme aims to ensure that advisers give reliable advice on fertiliser use, that training standards are raised and that environmentally friendly farming is promoted (see Appendix 1).

[29] A new BASIS Soil and Water Management Certificate provided by the Association of Independent Crop Consultants and the National Soil Resources Institute is to be launched at Cereals 2004. The new qualification has been endorsed by DEFRA and aims to help farmers and advisers grapple with new environmental regulations and meet new cross compliance requirements of maintaining land in Good Agricultural and Environmental Condition (Farmers Weekly 2004b).

practices or adopt anti-pollution measures such as buffer strips, mostly through participation in agri-environment schemes. FWAG for instance has increased its role in environmental protection. In 1998/99 FWAG advisers were providing pollution and fertiliser management advice in 44% and 53% of cases respectively, representing a significant increase (some 20%) since 1992/93 (Winter 2001 et al.). Archer (2001) however, reports competence for this advice in only a few FWAG individuals who are FACTS trained. Clearly a range of competencies and skills among advisers exists. Aligned to this is evidence that there is a range of perspectives about sustainable practices as well (Wilson et al. 1999; Wilson 2001). This review highlights the poor state of understanding of the contemporary capabilities of advisers with regard to soil management. Although more recently attention has been directed towards farmers' knowledge and skills in soil management, albeit in other countries (Romig et al. 1995; Walter et al. 1997), advisers' knowledge of, and skills associated with, managing soil remains unexplored.

2.8.5 Potential of advisers for facilitating soil best management practice

Those pointing to the strengths of commercial consultants argue that they are the advisers who establish regular one to one contact with farmers, they are valued and trusted by farmers and most importantly they can interpret information at the farm level (Jones et al. 1987; Gasson and Hill 1996; Dampney et al. 2001)[30]. Because of this relationship with farmers there is also a strong feeling amongst advisory services that the most successful method of getting environmental protection messages across to farmers is likely to be an agriculturist with some environmental training (Winter 1995). Archer (2001: 17) envisaged such a role for consultants and talked of 'influencing the messengers' seeing scope for DEFRA to improve the dissemination of new knowledge to those who are able to use it in their day-to-day work with farmers. He states 'If a consultant who has a number of farmer clients is persuaded of a particular beneficial management technique, he or she is likely to be a very effective multiplier of the message'. Drew Associates (2003: 40) echo these views but also raise concerns about the experience of the consultant, stating 'in many cases effective adoption of research based solutions will not be achieved without the

[30] The role that advisers play in facilitating farmer-farmer interaction is also recognised (Roling 1988).

contribution of a consultant who is *experienced* in both the particular aspect of research and the particular farming systems'. They found concern in the farming industry about the small number of people experienced in communicating soil research to farmers and recommended that consultants are kept up to date to achieve maximum uptake of research by users. A further concern is that commercial advisers and their clients will perceive DEFRA's soil protection messages as cost negative or at best cost neutral to the farm business (Drew Associates 2003). These apparent constraints to advisers facilitating the transition to sustainable soil management will form a central element of this research.

The fact that soil best management practices are voluntary and that they are non-prescriptive makes the agricultural advisers' role more important and arguably more complex. Knowledge about these practices will not necessarily be uniformly available nor in a standard form, these practices are therefore open to different interpretations. The effect of advisers' interpretation in delivering agri-environment scheme advice was described by Cooper (1999) and Juntti and Potter (2002); and the effect of advisers' different understanding of what constitutes sustainable systems such as organic farming was demonstrated by Seppanen and Helenius (2004). Given the broad canvas of options for soil best management practice, their complexity, the heterogeneity of farm soils, and the differing demands of farmers, variable interpretation of these practices by advisers is likely to be considerable. This is particularly the case given the range of attitudes and skills identified within the advisory community (Wilson 2001; Marshall 2002).

2.9 Advisers involved in soil best management practice advice in England

Given the diversity of advisers described in the AKS in England, there is a need to identify those most likely to have some impact on soil best management practice. As these practices are not specialist technologies but integral to all farm practices they become the potential remit of a number of arable, environmental protection and conservation advisers. At the same time opportunities for involvement in soil best management practice are expanding in a more open and flexible AKS, in particular as advisers engage within project contexts, rather than exclusively on-farm. Advisers supporting farmer soil management decisions, in the broadest sense, fall into two broad, but not necessarily exclusive, categories:

- Arable advice providers: These advisers support crop production and the farm business and include: on-farm agronomists in the independent sector who are fee earning and those in the trade sector who charge 'through the can'; agricultural consultants; advisers working with farmer funded organisations and advisers attached to collaborative projects and knowledge transfer initiatives and NGOs.

- Public good providers: Advisers whose objective is protecting the environment, enhancing environmentally responsible farming and conservation who work for ADAS, RDS, FWAG, NGOs, collaborative projects and in knowledge transfer initiatives.

More detailed information about these advisers is presented in Appendix 2. This categorisation concurs with that made by Gasson and Hill (1996) who distinguished different extension (public good) and consultancy (commercial arable) sub systems in the AKS, arguing that extension agents take the results of research and process them into messages while consultants translate extension messages into individual advice; the former relying more on mass extension and the latter on one to one interaction. In many cases, however, this distinction does not hold up in practice.

The key point to emerge from this review is that no single advisory community provides soil best management practice advice to farmers. Instead, the farmer will receive this indirectly within agronomic, environmental protection, RDS scheme and conservation advice.

2.10 Chapter summary and research issues identified

Soil has a multifunctional role, which is central to economic, social and environmental sustainability. In recognition of this, policies and legislation are being developed in England, which aim to sustainably manage this crucial resource. Research priorities reflect these policy aims and have focused on the development of best management practices in which sustainable soil use is integral. Farmers need support and information to implement such practices and the advisory community has always been central to providing such support. The structure of the AKS, however, has implications for the ability of agricultural advisers to effectively support a shift towards soil best management practice. Increased pluralism and fragmentation in the policy, research and advisory sectors, which collectively comprise the AKS, together with a growing and more influential environmental movement and a strong commercial sector has resulted in what Winter et al. (2001) calls an 'open AKS' in England. The diversity of advisers all with their own objectives and no central soil advisory body could mean that best management practice for soil advice is peripheral, fragmented, uncoordinated and delivered sporadically, exhibiting signs of a horizontally fragmented service. However, although there are concerns about horizontal and vertical fragmentation of the AKS, there are also opportunities for more creativity and networking within a more dynamic AKS. Arguably opportunities are improving for advisers from all sectors to move away from their traditional roles and alliances and contribute to the implementation of soil best management practice within a more flexible AKS. These alternative interpretations clearly require full examination in this research.

This review has established that advisers can be potentially influential players on the farm in terms of facilitating sustainable soil management and that they are a diverse community and hold an equally diverse set of objectives, skills and knowledge. The complexity of soil best management practices being promoted, both in terms of scientific understanding and practical application, and the need for a knowledgeable adviser community to support such practices has also been noted. Knowledge therefore is a central theme. The importance of knowledge in agriculture has been identified by Winter (1997) who regards it as the fourth factor of production equal to labour, land and capital and highlights the significance of widely differing knowledge, skills and aptitudes land managers bring to the production process. The theme of knowledge has also occupied those discussing sustainable agriculture, many of whom consider that more sustainable practices are complex and more knowledge intensive than conventional practices thus making new demands on land managers (Kloppenburg 1991; Roling 1993; Winter 1997). These observations suggest that knowledge should be a central element in research concerned with the transition to sustainable soil management in England.

Given this context it is now necessary to consider the ways in which knowledge and advisers can be linked together in a study of sustainable soil management. There have been a variety of studies in rural social science (notably rural sociology and geography and extension science) concerning the relationship between information, knowledge, advice and sustainable management practices which might inform this study. These understand knowledge, and the processes that enable its creation, dissemination and utilisation, in different ways and as such offer a number of possible approaches for this research.

Many of these studies understand knowledge in terms of behaviour. These derive from a tradition which attributes decision making behaviours on-farm to farmer attitudinal or social psychological factors. This approach has been employed in the UK, where researchers have looked to behavioural and attitudinal factors as determinants of farmer decision making in environmental conservation management and scheme participation (Brotherton 1991; Carr and Tait, 1991; Morris and Potter 1995; Wilson 1996; Beedell and Rehman, 1999, 2000), and outside the UK in studies of soil conservation (Napier et al. 1984; Lynne, et al. 1988; Duff et al. 1991). These studies have focused almost exclusively on the farmer as the ultimate decision maker, rather than the adviser. Some references have been made to advisers' negative perceptions of the environmental agenda (Eldon 1988; Curry 1997; Wilson 2001) and to the range of opinions held about sustainable agriculture (Wilson 2001) suggesting that some researchers are beginning to consider adviser attitude, motivation, goals and values as an important area for research. Although such an approach might offer some opportunities for exploring advisers' decision making with regard to soil management advice provision, it fails to provide an adequate basis for understanding the actual knowledge they hold and impart about soil nor does it understand the significance of knowledge in the context of more complex sustainable practices.

The term 'knowledge transfer' has underpinned a number of studies in agriculture, which in fact examine and describe the provision and communication of *information* rather than knowledge. Provision of, and access to, information has been considered synonymous with knowledge in studies of farmer decision making. For example, in seeking to explain farmer adoption of soil conservation and other environmental measures in the USA, access to information was highlighted as an important determinant (Korsching and Hoban 1990; Feather and Amacher 1994; Lichtenberg and Zimmerman 1999). The contribution that information makes to the effectiveness of the advice system in UK has also been the subject of evaluation in UK (Craig 1979; Jones et al. 1987; Craig 1995). In these studies emphasis has been on the institutional capacity to provide information, while advisers are consigned to the role of neutral provider of information, the significance of their knowledge, competence and skills neglected.

Other knowledge transfer studies have focused on communication as a process for transfer of information between individuals where the overall purpose is to make another party more knowledgeable (Ramkumar and Rolls 1995). For example, the effectiveness of different communication methods and the connections between different institutions, or knowledge networks, in the UK AKS have been examined (Jones et al. 1987; Winter 1995; AERDD 1996; ECOTEC 2000; Dampney et al. 2001). Face to face advice from an adviser has been studied as one possible communication method and, although recognised as important, the focus has been on the delivery mechanism rather than the competence and knowledge held by the deliverer.

Within these various approaches advisers are considered to be deliverers of information rather than knowledge. In taking such a focus on information rather than knowledge and the interaction of those holding knowledge these approaches have failed to provide any insights into the contribution advisers can make to sustainable soil management as knowledgeable and interacting actors. To achieve such insights it is first important to elaborate the relationship between information, advice and knowledge. Although these terms are often used interchangeably they represent concepts which are qualitatively different (Davies 1994; Ramkumar and Rolls 1995). Information comprises facts, interpretations and projections which reduce the uncertainty faced by decision makers (Garforth et al. 2002). However, it is how people understand information and attribute meaning to it that turns this information into knowledge (Wilson 1987)[31]. Advice, on the other hand, implies the recommendation of a particular course of action, or the presentation of a range of alternatives (Garforth et al. 2002) based on this acquired knowledge. In short, these distinctions imply a processing or transformation of information into knowledge that is then used as a basis for advice. By making these distinctions the significance of the *knowledge processes* that turn information into knowledge and knowledge into advice become apparent.

This has particular pertinence to the advisers' role in facilitating sustainable soil management since they are central to the process of using information and tailoring it, or transforming it, through individual judgments to provide on-farm advice which is relevant to specific soils and farm businesses. Only recently in studies of agri-environmental policy implementation have researchers sought to understand such interpretations of information, and the judgements and strategies that advisers engage in as they advise farmers (Lowe et al. 1997; Cooper 1999; Burgess et al. 2000; Juntti and Potter 2002). This recognition, that advisers can interpret and transform information and create knowledge, is coincident with the shift in understanding of how farmers interpret and construct conservation advice (McEachern 1992; McHenry 1997).

Knowledge processes are also critical in the context of communication in the AKS where advisers play an important role in moving, exchanging, changing and combining information and knowledge. In the complex and fragmented AKS described earlier in this chapter where advisers are involved in multiple connections and networks these processes become more significant. These processes are more complex than simply providing information, as Winter (1997:14) argues there is 'more to agricultural progress than enabling the flow of knowledge to farmers, as though that is in some sense a neutral activity'. At every stage of the production and dissemination of knowledge choices have to be made by the actors involved about what to impart to the farmer. Advisers engage in such choices daily. This view that

[31] The distinction between information and knowledge has been made by a number of commentators; Ramkumar and Rolls (1995) provide a useful review. These distinctions are considered further in Chapter 3. Information is thought to be is transformed into knowledge through a process of perception, cognition and understanding (Ramkumar and Rolls 1995). Davies (1994) described knowledge as the absorption, assimilation, understanding, and appreciation of information.

knowledge exchange is not dispassionate but involves processes of choice, learning and social interaction is also considered as key to achieving sustainable agriculture (Pretty 1995). By understanding knowledge processes rather than information transfer an appreciation of these aspects in the context of facilitating sustainable soil management might be gained.

Rather than focusing on advisers' behaviour, attitude or the communication mechanisms they use, it would appear that it is more important to understand the knowledge processes that create, mix, move and combine information and knowledge. This thesis, therefore, seeks to build on and extend the studies discussed above by taking a new approach which explores the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about soil best management practice; and seeks to understand the factors that enable and constrain these knowledge processes at the interfaces between advisers and farmers, and between advisers and research scientists, within the AKS in the context of new policy developments and concerns which seek to promote a shift towards more sustainable soil management. As such, the objectives of this research are:

- To provide detailed empirical evidence of the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about sustainable soil management;

- To elicit the factors that enable and constrain these knowledge processes;

- To make a contribution to the conceptualisation of Agricultural Knowledge Systems surrounding sustainable soil management in England;

- To make policy relevant suggestions for improving the operation of the Agricultural Knowledge System in order to achieve more sustainable soil management.

Chapter 3

CONCEPTUALISING KNOWLEDGE PROCESSES IN THE CONTEXT OF SUSTAINABLE SOIL MANAGEMENT

3.1 Introduction

Addressing the objectives set out in the preceding chapters requires that they be situated in a conceptual framework, which can provide a basis for gathering and analysing the research data and explaining the results. As elaborated in the previous section the processes that advisers engage in which create, mix, move and combine knowledge about soil best management practice within the AKS can be collectively understood as knowledge processes. In this chapter literature from different disciplines will be reviewed and combined in order to develop a new conceptualisation of knowledge processes which is applicable to this research.

Chapter 3 has two sections. Section 3.2 provides a review of different conceptualisations of knowledge processes in terms of understanding the frameworks and the context in which they operate. It develops a new actor-oriented-AKIS conceptualisation which can be used to structure and understand this research. Section 3.3 goes on to elaborate on the details of the knowledge processes operating within these frameworks and develops a case for understanding them within the actor-oriented-AKIS as interactive social processes.

The study of knowledge and knowledge processes has been an expansive area within rural social science and there are many different perspectives on the phenomena and a variety of methods of gathering information and analysing results. This introduction provides a brief overview of how such perspectives have developed within a range of relevant literatures in response to different challenges and highlights some of the approaches which have particular relevance to this study. Conceptualisations of knowledge processes, which have developed in the context of agriculture, are grounded in two different views of knowledge and knowing, positivist and constructionist. Different perspectives used to understand knowledge processes within the disciplines of rural geography, rural sociology, extension science, communication science and development sociology have been informed by these two epistemologies.

Positive epistemologies, which produce scientific knowledge through a process of reductionism, have come to be regarded as the unique and dominant mode of knowledge production in conventional agriculture. The positivist perspective regards knowledge as a tangible stock to be tapped, stored, documented and exchanged between homogenous categories of actors. This underpins the concept of knowledge transfer inherent in adoption-diffusion of innovation and transfer of technology models which have until recently dominated rural sociology and extension practice (Rogers 1983). Knowledge transfer focused on knowledge production, communicative intervention and knowledge consumption measured as behavioural change. Socio-physiological characteristics of individuals, their goals and values, and state of knowledge are thought relevant to understanding how farmers use knowledge in decision making and empirical approaches have sought to discover patterns or predictive factors in the way decisions are made (Ilbery 1978; Earle et al. 1979).

However, partly as a result of the advent of sustainable agriculture, researchers have sought a new set of conceptual perspectives. The transformation to sustainable agriculture is thought of as a process which requires incremental learning and adaptation based on communication through mutual interaction between actors (Roling 1992; Roling and Jiggins 1994; Pretty 1995; Petrzelka et al. 1997; Morgan and Murdoch 2000) and new perspectives, beyond the production and consumption of knowledge, are thought necessary to understand the interactive processes of knowledge flow and exchange

Soil best management practices, such as reduced tillage and nutrient budgeting, are qualitatively different from the simple adoption of new one-off techniques. They are complex, knowledge intensive and loosely coupled systems[32] and demand a whole-

[32] Coughenour (2003) uses the concept of 'loosely coupled systems' to describe non-prescriptive systems where the structure and activities are only weakly connected. In contrast in 'tightly coupled systems' the system components are functionally interdependent. The more loosely coupled the

farm change. Positivist approaches, it is argued, can only provide partial and limited understanding of knowledge within such systems (Nowak and Korsching 1998). Constructionist perspectives, which emphasise multiple realities rather than the 'objective truth' of the positivist approach, are considered more suited to conceptualising knowledge processes within these systems (Roling and Jiggins 1994). These perspectives view knowledge as socially constructed and understand that knowledge, rather than a transferable commodity, is diffuse and fragmentary emerging through social interaction and negotiation and constructed through learning and experience (Roling and Wagemaker 2000).

This paradigm shift reflects wider changes in the disciplines of rural and development sociology and rural geography during the 1980s and 1990s where culturalist or subjectivist views emerged in a post-Marxist era to counter the perceived determinism of political economy (Buttel 2001). The 'cultural turn' was a product of such influences within rural studies scholarship (Cloke 1997; Little 1999; Morris and Evans 2004). This change also reflects new understandings of knowledge in science. Sociological interpretations of science have emerged which draw on a diverse body of theoretical and empirical resources to challenge positivist and realist epistemologies of scientific knowledge (Knorr-Cetina 1981; Law 1986; Latour 1987). Although the analytical frameworks associated with the new sociology of science are theoretically and methodically diverse they share a central tenet, that 'mental productions we call scientific knowledge are no less subject to social influences than are the products of any other way of knowing, they are 'constructive rather than descriptive' (Kloppenburg 1991:524).

A range of analysts have tried to explore distinctive ways of knowing the world through elaboration of paired concepts such as codified/tacit knowledge (Polanyi 1966; Lundvall and Johnson 1994); scientific/local (Roling 1994; Morgan and Murdoch 2000) and indigenous/scientific knowledge (Richards 1985). With reference to the new demands of sustainable agriculture many argue that decontextualised scientific knowledge is unsuitable because it offers only partial understandings of widely dispersed phenomena (Kloppenburg 1991). In contrast

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system that a person constructs, the more the system operator engages in its construction and operation.

local knowledge, which is strongly rooted in place and constituted from a 'mixture of intuitive wisdom of experienced practitioners', is thought to be more suited to complex and 'ecosystem-sensitive' sustainable practices (Norgaard 1984; Roling and Jiggins 1994; Hassanein and Kloppenburg 1995). Studies of farmers' knowledge about soil reflect these views (Romig et al. 1995; Sillitoe 1998; Talawar and Rhoades 1998). Others, however, suggest that categories themselves are not relevant but that it is the merging and blending of different forms of knowledges which is more important to achieving sustainable agriculture (Arce and Long 1992; Murdoch and Clark 1994; Clarke and Murdoch 1997; Winter 1997; Morgan and Murdoch 2000). Scoones and Thompson (1994) for instance argue that emphasis on local knowledge detracts attention from the process of knowledge construction. Some commentators develop this idea further describing knowledge not as a fixed thing but fluid and changing, the outcome of a set of processes (Long and van der Ploeg 1994; Murdoch and Clark 1994; Clark and Murdoch 1997). It is the process of knowing therefore which is important, not the form of knowledge.

Given these understandings and considering the different orientation sustainable practices have towards agriculture and the environment in terms of their perceived dependence on multiple forms of knowledge, perspectives are needed that do not privilege and uncritically accept one set of actors or forms of knowledge as central but instead accord the same status to all (Murdoch and Clark 1994; Coughenour 2003). This equity is seen as particularly important as according to Coughenour (2003: 280) sustainable practices like conservation tillage 'entail a qualitative change in agriculture that engages multiple actors, agencies, institutions and farming environments in a long process of social construction of new techniques.... and institutional structures'. Divergent analytical integrative approaches have arisen to accommodate these ideas. These have evolved within different disciplines to address different issues, but some have particular relevance to this research.

Constructionist perspectives emerged both in rural geography and development sociology in an attempt to address the dualism of external and internal factors affecting farmer decisions (Long 1989; Box 1990; Arce and Long 1992; Ward and Munton 1992; Marsden et al. 1993; Long and van der Ploeg 1994). These understand that individuals hold divergent interests and goals and access to resources and that structural forces are given meaning and transformed at the micro–level by the actor. This actor perspective has also been used to understand the confrontation of actors' different perspectives and knowledges conceptualised as 'interpretative struggles' (Lowe et al. 1994; McHenry 1997). This view, which emphasises the significance of actor negotiations across interfaces, may have some relevance to this study of individual adviser interfaces and the processes operating across them in the AKS.

Rural sociologists and rural geographers have focused on the confrontation of incommensurable forms of knowledge such as between conservationists and farmers and some have favoured Actor Network Theory (ANT) as a constructionist integrative method to understand how knowledge is integrated, absorbed, legitimated, extended, and translated (Murdoch 1997; Cooper 1999; Burgess et al. 2000; Murdoch 2000). ANT provides a useful device for understanding the translation of an innovation in an agricultural community, it does not however, enable the nature of the knowledge processes to be revealed nor the factors that enable or constrain them, focusing as it does on the translation of an idea or innovation. In the same way, although knowledge networks have been a useful device for exploring patterns of communication and interaction among social actors who share a common concern (Box 1990; Winter 1995), they do not enable a detailed account of the processes to be determined. Similarly social networks and the contribution made by social capital have been shown to be important to the spread of sustainable agriculture, again there are limitations in these conceptualisations in elaborating knowledge processes (Hassanein 1999; Sobels et al. 2001).

In extension, the provision of advice is considered essentially as a communication process. Earlier linear top-down models have been replaced by interactive models of communication, which highlight the fluid roles and varying objectives of those involved. An emphasis on seeking to develop new understandings between parties to the communication process has supplanted the notion of senders, receivers and messages (Black 2000). Joint learning perspectives are central to participatory approaches in extension practice which emphasise collective learning, reflection, sharing and innovation amongst stakeholders and are thought more suited to sustainable agriculture (Engel 1997; Campbell 2000; Cerf et al. 2000; Roling and Wagemaker 2000). One such learning based approach is 'action research' which offers a powerful model for coping with situations where humans and technical issues interface, norms are under challenge and ownership of the problem is crucial. These perspectives, although offering some relevance to this study, have been developed as analytical tools rather than as a conceptual basis for research. They also reflect progress in international development circles, not those of the AKS in England. More recently extension science has looked to perspectives that equate knowing to learning and see knowledge as created through the transformation of experience (Kolb 1984; Engel 1997; Cerf et al. 2000; Ison et al. 2000). The dynamic unity of learning and doing as opposed to static conceptions of knowledge as statements is central to this understanding (Maturana and Varela 1987).

Systems thinking has been used to describe the emergence of knowledge and innovations within sets of articulated actors (Checkland 1981; Checkland and Scholes 1990) and forms the basis of integrative perspectives used in extension science to explain complex arenas of actors and their institutions in agriculture (Engel 1997; Ison and Russell 2000). Knowledge systems, for example, have provided a particularly valuable framework and diagnostic tool for understanding knowledge exchange and innovation in an agricultural context (Roling 1990). This perpsective can provide a useful framework in which to reveal the knowledge processes occurring between different actors in the system and to examine the factors that enable and constrain them.

This range of perspectives drawing on diverse disciplines including philosophy, sociology, extension science, rural geography, rural sociology, education, and development sociology demonstrate the challenges researchers have faced in understanding knowledge and knowledge processes in the agricultural context and how sustainable agriculture has brought new demands. Most importantly the development of these perspectives has shown that understanding the transformation to sustainable agriculture cannot be accomplished on the basis of positive science. This view must inform the conceptualisation of adviser knowledge processes in the context of sustainable soil management.

The following sections will develop a conceptualisation of the knowledge processes that advisers engage in. Section 3.2 is concerned with the context in which knowledge processes operate while section 3.3 discusses the details of the processes themselves.

3.2 Theoretical perspectives for conceptualising the context of knowledge processes

This section is concerned with understanding the context of adviser knowledge processes as distinct from the processes themselves which are discussed in section 3.3. It describes the evolution of the concept of Knowledge Systems in response to changing agricultural conditions and academic critiques, and develops a new conceptualisation for understanding advisers' knowledge processes in the context of sustainable soil management based on the incorporation of constructionist perspectives into the concept of the Agricultural Knowledge and Information System. Figure 3.1 provides a schematic representation of this development and is designed to assist the reader in understanding the relationship between the distinct but related concepts of knowledge and knowledge processes as well as explicitly relating the actual shift from productivist to sustainable agriculture to concepts of knowledge and knowledge processes.

As section 3.1 explained, an understanding of knowledge processes in an agricultural context has been underpinned by two different theoretical views of knowledge, firstly a positivist view that knowledge is a discrete, tangible commodity which could be transferred between actors and secondly a constructionist view that knowledge is socially constructed, diffuse and fragmentary and cannot be transmitted. Whilst the former has been used to understand knowledge processes within conventional agriculture, a shift towards sustainable agriculture has focussed interest on the latter. These developments are discussed exploring how this shift has brought a change in the way that the context in which knowledge processes operate is understood. Section 3.2 goes on to examine the processes themselves in detail.

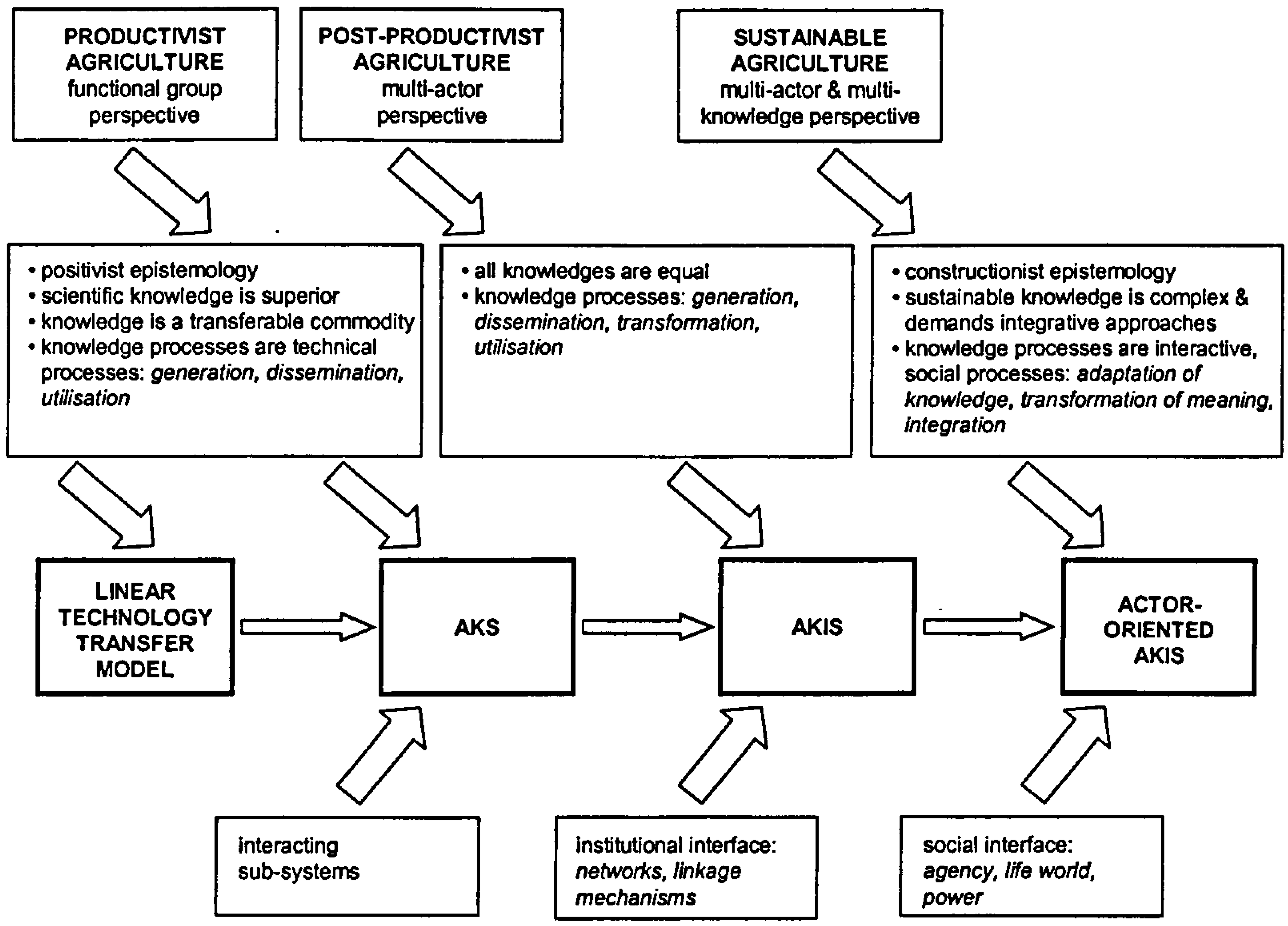


Figure 3.1 Developing an actor-orientated AKIS conceptualisation.

3.2.1 Linear perspectives for conceptualising knowledge processes

A number of approaches to conceptualising the context in which knowledge processes operate have arisen within the so-called 'transportational paradigm' (Dissnayake 1986: 280) which views knowledge as a transferable item and emphasises communication and knowledge transfer as the key processes. In this paradigm, which characterises much traditional extension, knowledge or innovation is seen to originate in science and is realised through transfer and adoption of the results of science following a linear and sequential route (Chambers 1983; Roling 1990; Black 2000). This notion of a one way path has been developed and adapted by a number of authors, most pervasive being the diffusion of innovation theory articulated by Rogers (1983) and the technology transfer (TOT) model which until recently has underpinned the activities of most extension services (Roling 1990; Ruttan 1996; Black 2000). Implicit in these models is that knowledge is a transferable item and knowledge processes are discrete processes of knowledge generation, transfer and utilisation undertaken exclusively by functional groups of researchers, disseminators and farmers respectively, where advisers are primarily involved in the dissemination or transfer of knowledge. This linear paradigm captured the concerns of the productivist era of the 1970s and 1980s describing the translation of science to encourage and promote efficient and profitable production. This model is represented as the starting point for the development of conceptualisation for this research, as represented by Figure 3.1.

Critics have argued that the knowledge transfer paradigm and the realist positive epistemology in which it is embedded are increasingly inconsistent and irrelevant to modern agriculture, which has multiple goals and demands more stakeholder negotiation and agreement. Specifically researchers argue that this 'top down' model does not reflect the actual processes occurring (Roling 1992) and fails to represent the many different sources from which knowledge is generated (Chambers et al. 1989; Kloppenburg 1991; Leeuwis et al. 1991; Leeuwis 1993a,b, 2000; Ruttan 1996; Roling and Wagemaker 2000). The assumption that actors perform according to discrete functional categories is also criticised (Leeuwis et al. 1991), as in reality social divisions do not coincide neatly with the functional roles assigned to researchers, advisers and farmers as generators, transferers and users but instead they operate as a complex whole (Box 1989; Roling 1992). These criticisms led to the passing of what Rogers (1986) calls a 'dominant paradigm' as it was accepted that it no longer described the more complex AKS of modern agriculture. For the purposes of this study the transportational approach fails to fully describe the diversity of actors within the open and fragmented AKS which exists within England today (Winter 1995; Gasson and Hill 1996). The following section describes successive developments in conceptualisation of knowledge processes, as represented by Figure 3.1, and discusses their application in the context of this study.

3.2.2 Emergence of the Agricultural Knowledge Information System

In recognition of the inadequacies of previous models in explaining the complexity of modern 'post-productive' agriculture, a Knowledge Systems perspective emerged in which research, extension and farmers were conceptualised as forming articulated and interactive systems as shown diagrammatically in Figure 3.2 (Nagel 1980; Roling 1985,1988; Havelock 1986). This idea evolved during the 1980s and 1990s into the Agricultural Knowledge and Information System (AKIS) concept (Roling

1988; Engel 1990) which offers a multi-actor perspective designed to deal more effectively with complexity and with the diversity of information sources and channels. Figure 3.1 represents this evolution. In particular it recognises that all actors in the system engage in all knowledge processes, thus advisers are credited with being involved in all processes (Roling 1988, 1992; Engel 1990). The AKIS is defined[33] by Roling (1988) as:

> 'the persons[34], networks and institutions and the interfaces and linkages between them, which engage in or manage the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of knowledge and information, which potentially work synergically to improve the goodness of fit between knowledge and the environment, and the technology used, in a specific domain of human activity'.

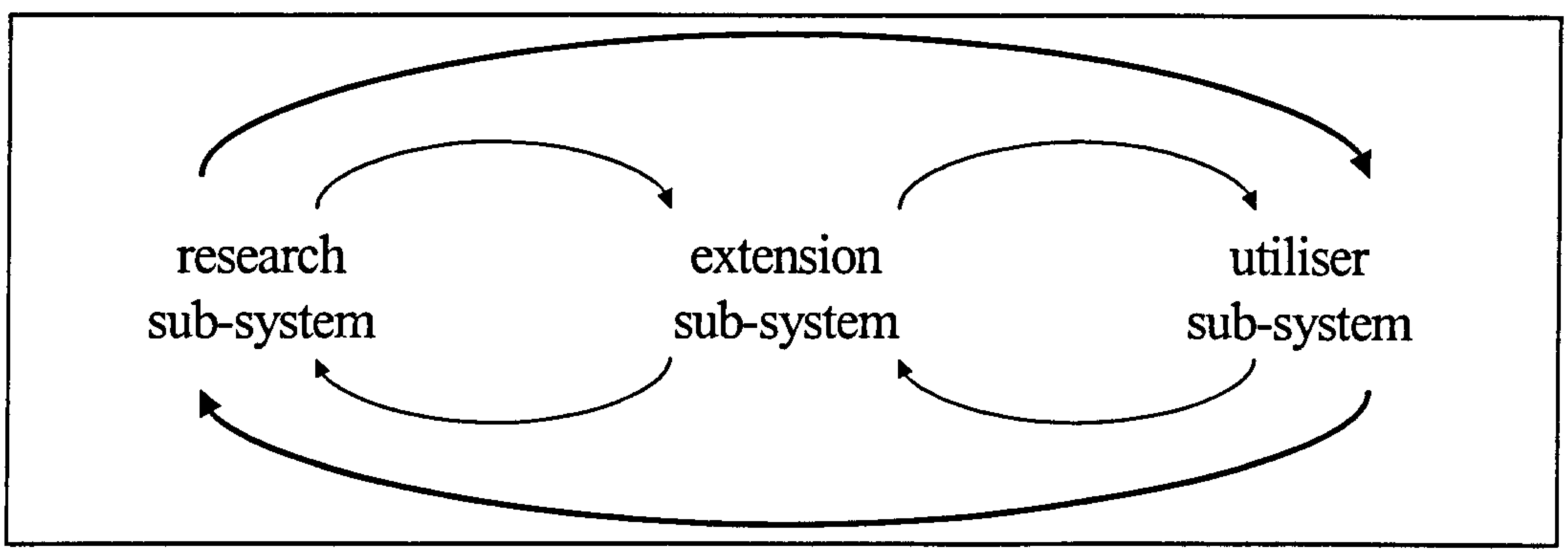


Figure 3.2 The AKS (Roling 1985).

As demonstrated in Chapter 2 the AKS concerned with soil in England is characterised by a diverse and dynamic adviser community actively engaged in a range of relationships (Winter 1995; Garforth et al. 2003). The AKIS therefore provides a useful framework in which to situate and make sense of this complexity. Significantly, by using this AKIS concept, all actors in the AKIS in England, including advisers, can be credited with engaging in all knowledge processes, advisers therefore are no longer consigned to being solely disseminators.

[33] Definitions of the AKIS have evolved over the years, eg. Roling and Engel (1990); Roling (1992).
[34] 'persons' was changed to 'articulated set of actors' in Roling's 1992 definition (Roling 1992).

The AKIS perspective evolved to provide a diagnostic framework and can be used to unearth the organisational structure that enables and/or constrains knowledge processes. It focuses on actors and organisations and the structural links and interactions between them. It provides an institutional, policy and regulatory setting in which to situate the advisers, farmers, researchers, policy makers, and their organisations, interfaces and other linkages. Effective communication and integration of the system are emphasised in the AKIS perspective. These are achieved through strong linkages across organisations, which are called interfaces, and the strength of the interface is likened to a 'force field' between two institutions (Roling 1990). Roling (1990) describes the 'institutional interface', which is found at the intersection between the institutional structures of research, extension and farming. This is conceptualised primarily as a bridge between research and technology where major transformations of knowledge, information and technology take place as shown diagrammatically in Figure 3.3. Although it is recognised that interfaces between researchers and farmers exist, this research is concerned with adviser interfaces with research and with farmers.

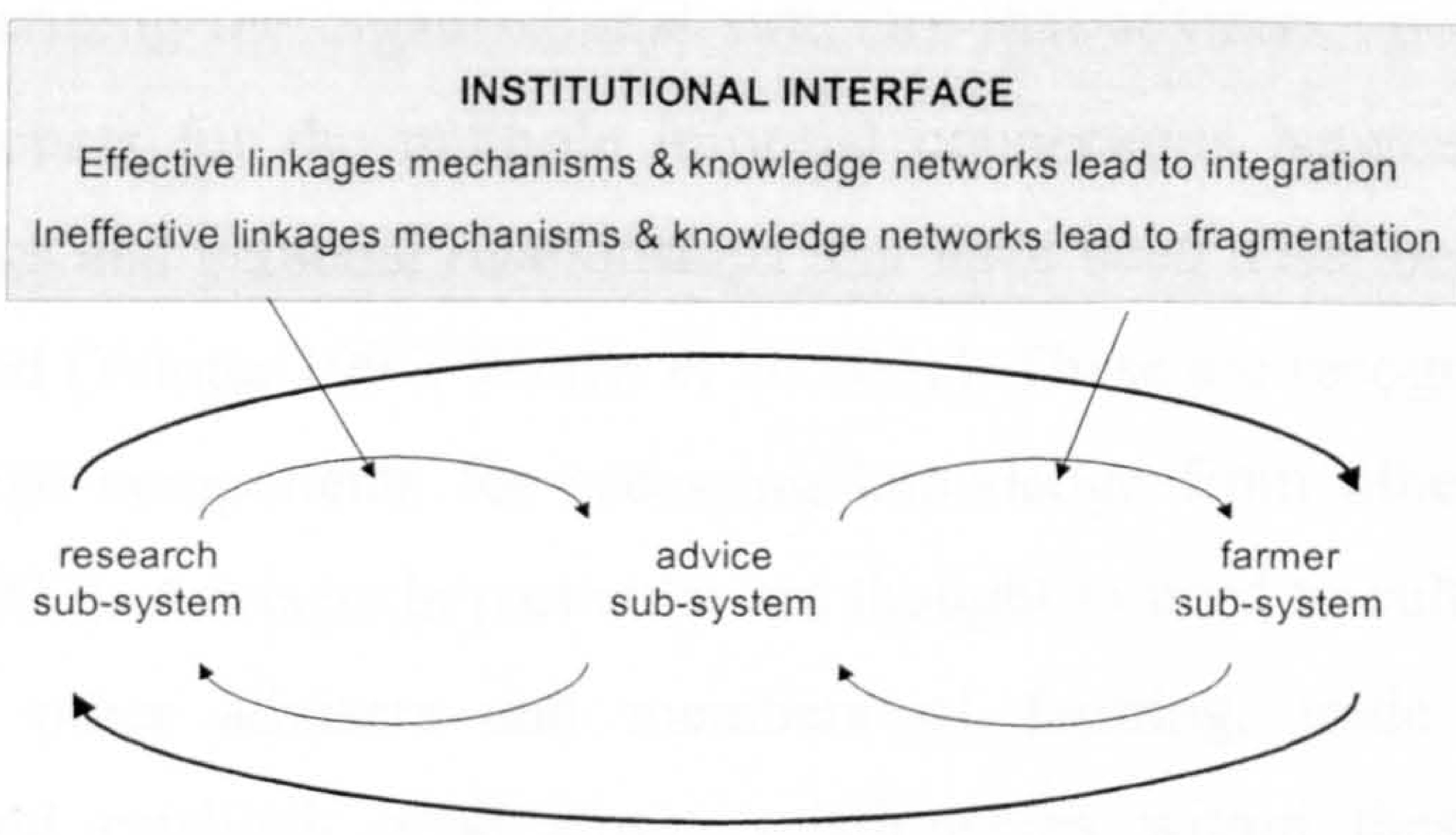


Figure 3.3 Linkage mechanisms and networks across institutional interfaces within the Agricultural Knowledge Information System[35].

[35] As it is not possible to fully represent such a complex model as the AKIS diagrammatically, a simple representation has been used in this and the following diagrams in the understanding that there are numerous actors and linkages both within and between the different sub systems shown.

This element of the AKIS is particularly relevant to advisers in this research as they are situated at the interfaces between these institutions and can therefore be considered as being central to the major transformations of knowledge that occur across them. Effective spanning of interfaces is achieved through good linkage mechanisms, networks and other structural elements like funding and contracts which collectively act to maintain or improve the overall effectiveness or integration of the AKIS (Kaimowitz 1990; Roling 1990). Linkage mechanisms are specific organisational procedures or devices like face to face advice, training, and demonstration plots, seminars or publications that operate across the interface. Clearly advisers provide a vital linkage mechanism in the AKIS in England, as well as rely on other formal linkage mechanisms to access and disseminate knowledge. The concept of institutional interface accounts for integration, where linkages are strong and effective, and fragmentation or 'fatal gaps' where these linkages and networks fail (McDermott 1987; Winter 1995; van Crowder and Anderson 1997). Such fragmentation has been described in the AKIS in England where institutional linkages are inadequate (Winter 1995), as discussed in Chapter 2.

As well as describing the organisational structure that advisers operate within, the AKIS also accounts for the multiple informal connections between AKIS actors through networks and personal relationships that have been described as part of the AKIS in England (Winter 1997; Winter et al. 2001). These are recognised as equally important linkage components for accessing knowledge from other actors in the AKIS (Engel 1997). Advisers in particular are thought to need to cultivate extensive networks with other advisers and members of farming, trade and scientific communities and establish good strong relationships within these networks to maximise their sources of information and be effective (Engel 1997). Increases in networking and other agency liaison was noted by Clark et al. (1997) as a new way of operating which bring clear benefits to actors and their organisations in terms of sharing place specific and sector specific skills and resources. Knowledge networking[36] as a basis for agricultural innovation and knowledge exchange has also been noted as a key device for the AKIS in England and elsewhere (Box 1990; Winter 1995; Winter and Murray 1998). Together linkage mechanisms and networks

[36] Knowledge networks are defined as 'the more or less formalised relatively stable patterns of communication and interaction among social actors who share a common concern' (Box 1989:76).

can be thought of as both enabling and/or constraining knowledge processes within the AKIS. Networks in particular demonstrate that advisers can act as autonomous agents determining their own degree and extent of accessing knowledge from others irrespective of institutional structures.

The AKIS provides a useful framework in which to situate and make sense of the diverse and dynamic advisers' community described in Chapter 2. The significance of the institutional interfaces for advisers has been identified in terms of linkage mechanisms. Networks have also been described as a powerful device which advisers use to make horizontal and vertical connections with other actors. However, although the AKIS provides a useful basis in which to place this study, it is questionable whether it fully explains the increasing demands placed on advisers concerned with soil in the AKIS to respond to changing agricultural and environmental policy, the dictates of the market and consumer preferences. The evolution of the AKIS concept in response to such demands is described in the following sections and illustrated by Figure 3.1.

3.2.3 Knowledge and sustainable agriculture

AKIS is a useful framework for approaching modern agriculture but some have questioned whether it (according to earlier definitions) enables sufficient understanding of knowledge processes in relation to sustainable agriculture (Leeuwis et al. 1991). Sustainable agriculture, of which soil management is integral, requires new ways of knowing and, in response to criticisms, the AKIS has evolved and incorporated a number of theoretical and analytical perspectives which are relevant to understanding these new ways of knowing. These will be described in section 3.2.4 after an outline of how knowledge is conceptualised in relation to sustainable agriculture. Principally sustainable agriculture is thought to involve a shift in the paradigm of farming which can be achieved only by incorporating multiple knowledges and on the basis of social interaction and shared learning (Roling and Jiggins 1994; Pretty 1995; Petrzelka et al. 1997).

Commentators consider that complexity and the locally specific nature of sustainable practices are more complex and knowledge intensive (Kloppenburg 1991). The knowledge and management 'richness' of best management practices that impact soil such as IFS and reduced tillage are emphasised (Coughenour 2003); the need for 'clever' soil management which deviates from existing concepts of land use as well as more observation, monitoring and judgment are also stressed (Park et al. 1997; Auerswald and Kutilek 1998; Morris and Winter 1999; Tebrugge and Bohrnsen 2001).

In seeking alternative epistemologies to guide sustainable practice, some have looked to local knowledge, notably knowledge of the soil, (Roling 1992; Clark and Murdoch 1997; Sillitoe 1998; Winklerprins 1999; Koutsouris and Papadopoulos 2000) claiming that in being more ecosystem-sensitive and context dependent it is more relevant to sustainable practices than scientific knowledge (Leeuwis 2000; Morgan and Murdoch 2000)[37]. Others believe, however, that scientific knowledge is just as capable of finding sustainable solutions as local knowledge (Molnar et al. 1992; Pretty 1995). They argue that science is fundamental in underpinning the on-farm learning process and that elucidating processes, supplying a detailed knowledge of how natural systems work and providing the principles on which sustainable practices are based are central to sustainable agriculture (Miller and Rossman 1997; Jordan et al. 2000). The reliance on scientific research to achieve sustainable soil management in England is testament to this view.

Rather than giving preference to one particular form of knowledge, others believe that sustainable knowledge must be a mixture of the social, the scientific, the local, the technical, the natural and that the challenge for sustainable agriculture is achieving a hybrid between scientific solutions from both the natural and social world (Blum 1991; Arce and Long 1992; Murdoch and Clark 1994; Clark and Murdoch 1997; Morgan and Murdoch 2000). Black (2000: 496) for instance takes a middle road approach arguing that belief in a 'participation fix', which relies on local knowledge, maybe just as naive as a belief in a 'technology fix' based on scientific knowledge. New perspectives therefore have to give equal value to these different forms of knowledge and to their combination through processes of knowledge exchange and integration. New integrative mechanisms for enabling this mixing or

[37] This view has underpinned the development of 'farmer-first' ideology and participatory methods of extension championed by Chamber et al. (1989).

sharing of knowledges in the AKIS are also considered important for understanding and achieving sustainable agriculture. Rather than the traditional top down approach, which dominates conventional agriculture, characterised by experts intervening and providing bolt-on technologies through knowledge transfer, sustainable agriculture is thought to require incremental mutual learning and support, in which scientific knowledge is used to 'serve the process rather than lead it' (Roling 1993; Roling and Jiggins 1994). These mechanisms are discussed further in section 3.3.5. These considerations become critical to our discussion of advisers' knowledge processes in England in relation to sustainable soil management since advisers are increasingly required to both understand and facilitate farmers use of complex and knowledge intensive soil best management practice, as well as being encouraged to incorporate local knowledge through learning, participatory and integrative methods.

3.2.4 Incorporating constructionist views into the AKIS

To address the requirements of sustainable agriculture outlined in section 3.2.3 the AKIS perspective has been enriched by constructionist views, which recognise the multiple sources of knowledge and the social and interactive nature of knowledge processes. Constructionist thinking acknowledges a wider understanding of the constructed and contextual nature of knowledge, in which the facts associated with knowledge are believed to be social constructions, lacking an existence of their own but made by people in particular contexts (Knorr-Cetina 1981). The enriched AKIS accepts that knowledge is not made up of facts but rather is 'the concepts, ideas, insights and routines people use to impute meaning to events and ideas' (Box 1990:2), thus as Long (1992) points out knowledge is not simply something that can be possessed and accumulated. As such knowledge is described as implicit in individuals and social actions, as 'something that occurs between the ears, a property of the mind, which cannot be heard, seen or touched that cannot be transmitted directly, unless transformed or encoded' (Roling 1990; Engel 1997: 320). Knowledge is therefore understood as something that emerges and is transformed through social processes and as such knowledge processes are understood to be social processes (Scoones and Thompson 1994). To help understand and analyse these new assumptions, some researchers using the concept of AKIS have incorporated actor-oriented perspectives (Ward and Munton 1992; Ramkumar 1994;

Engel 1997). The key characteristics of actor-oriented perspectives and their central elements are considered below (shown in Figure 3.1) and discussed in relation to this research.

3.2.5 Incorporating actor-oriented perspectives into the Agricultural Knowledge Information System

Actor-oriented perspectives are based on an understanding that knowledge in agriculture does not exist, what exists are bodies of knowledge relevant to particular agrarian contexts, these contexts differing widely for each actor (ie. the expert, the adviser, the farmer) (Box 1990). As such, generation and exchange of knowledge can best be understood by relating it to the context in which construction and reconstruction takes place (Box 1990). This view is captured by Arce and Long (1988: 5) who state 'knowledge can be defined as constituted by the ways in which individual members of society or social groups categorize, code, process or impute meaning to their experience'.

This perspective, which regards knowledge as a property of the individual enabling them to make inferences from experience, observation and reasoning, has some relevance to how we understand the way advisers use, generate and transfer knowledge (Murdoch and Clark 1994; Engel 1997; van Beek 1997). According to Engel (1990), advisers are professionals with expertise, skills and techniques and individual competencies, they define problems and information needs, acquire information, learn skills and handle a diversity of sources and types of information.

The actor-oriented perspective is based on a number of defining principles and core elements which relate to knowledge, namely life worlds, agency, social interface and power. These have been developed by Long (1989, 1992, 2001) to explore how actors process, strategise and negotiate knowledge and have particular relevance to understanding how advisers as actors within the AKIS in England process knowledge about soil. The following discussion in this section is concerned with the relationship between knowledge and life worlds and agency and concludes by explaining why incorporation of these elements into the AKIS is necessary for this research. The relevance of social interface and power to adviser knowledge processes are elaborated in sections 3.2.6 and 3.2.7.

The actor-oriented approach contends that an understanding of knowledge processes must be situated in the 'life worlds' of the individuals and groups involved (Box 1990; Arce and Long 1992; Long and van der Ploeg 1994), where the life world depicts the 'lived in' or 'taken for granted' world of the social actor (Schutz 1962)[38]. Knowledge is perceived as a reservoir of interpretations which are embedded in the life world and which actors may draw upon in the creation of knowledge constructs (Waldenstrom 2002).

Life world is sometimes used synonymously with 'social field', which depicts sets of relations between actors oriented to the same goal (Turner 1974). This concept implies a degree of common commitment to a particular set of rules or values which Turner (1974: 17) has labelled 'cultural paradigms'. Other authors similarly consider knowledge as culturally bound, something which is accumulated, shared, passed on and reshaped from one generation to another (Havelock 1986). Placing knowledge in a sociocultural context implies that one recognises a relational notion not simply a material, tangible good (Portela 1994). Akin to life worlds (social fields and cultural paradigms), the concept of 'knowledge cultures' has emerged in which knowledge is understood to result from cultural practices that involve institutions, classes and groups. They are characterised by the practical understanding, which Shotter (1993: 31) refers to as 'knowledge that one has from within oneself as a human being and as a socially competent member of a culture'. It is a group's established way of making sense of happenings and events according to the rules, norms and values of that group. Knowledge processes are considered to be affected by social contingencies such as skills, orientations, experiences, interests, resources and patterns of social interaction of these particular groups.

This concept of knowledge cultures allows us to consider how advisers as social beings relate to, make sense of, and socially construct their environment and identities. Previous research has provided some evidence that advisers operate as

[38] Others similarly consider the life world to be composed of that which is perceived either directly or second-hand through mediation, as socially constructed through participation, and is intersubjective, in that it is constituted through interaction and communication with others (Busch 1978).

cultural groups. Tsouvalis et al. (2000b), for example, in a study of precision farming, considered that expert and farmer knowledge was informed by the social and physical contexts in which they work which led them to develop different ways of 'sense making' or interpreting what yield mapping actually was. Similarly in Australia studies found that groups of expert advisers perceived soil erosion and protection measures very differently from groups of farmers (Vanclay 1992). In the same way Ward (1995) suggests those advisers from commercial firms, acting as communities of practitioners, maintain traditions of technological practice such as pesticide use. In his analysis of the technological trajectory of pesticide use in UK he refers to Kuhn (1970) to describe this technical paradigm[39] as forming 'an entire constellation of beliefs, values, techniques and so on shared by members of a given (scientific) community' (Ward 1995:22). Lowe et al.s' (1994) investigation of the actors involved in water pollution from dairy waste also demonstrated how advisers (farm pollution inspectors (the NRA), ADAS officials and representatives of agricultural engineering) operate in different cultures and described how, as a result of different institutional contexts, they each have their own norms and practices. These observations would suggest that the notion of life worlds or knowledge cultures that underpins the actor-oriented approach is highly relevant to any discussion of advisers and knowledge and that inclusion of this element into the AKIS framework will provide a better understanding of the context of how advisers process knowledge about soil.

Another key aspect of the actor-orientated approach, as it relates to the AKIS, is that the multiple actors in the AKIS are characterised by relative autonomy, that each acts according to an individual strategy and agenda but that the AKIS enables and constrains them (Engel 1997). This approach, proposed by Long (1989), can be used to study the agent but also takes account of the context within which the agent operates. It acknowledges that actors have the capacity to strategise, recognising that at the same time enabling and constraining conditions will arise. As such agency is taken as a centrally important notion and this approach recognises actors as knowing and active subjects 'who problematise the situation, process information and

[39] Traditions refer to the momentum that technological systems achieve which arise when many groups have vested interest. Technological paradigms are seen as an extension of Kuhn's scientific paradigms (Kuhn 1970:175).

strategise in dealing with others' (Long 1989: 222); and actors are 'capable of formulating decisions, acting upon them and innovating or experimenting' (Long 1992: 224, referring to Giddens 1987)[40]. Scoones and Thompson (1994) bring together the elements of context, knowledge culture and agency describing rural peoples as 'situated agents'; as 'agents' because they are actively engaged in the generation, acquisition and classification of knowledge and 'situated' because this engagement occurs in cultural economic, agroecological and socio-political contexts.

The key assumption of this approach is that all forms of external intervention enter the existing life worlds of the individuals and are mediated and transformed by internal structures. Although centred on the actors, it acknowledges larger frames of meaning and action within the AKIS such as power, distribution of resources and institutional structures but recognises that these structural forces are given meaning and transformed at the micro-level by the actor.

Evidence has shown that advisers develop professional strategies to deal with information, to evaluate their experiences and to learn from them (Engel 1997). Researchers have described advisers acting according to an individual strategy and operational agenda, arguing that advisers create and defend a surprising degree of autonomy in handling knowledge and information against centralist tendencies to standardise their behaviour and messages (Engel 1990; Cooper 1999). This was also demonstrated by the way that key actors involved in water pollution from dairy waste in the Devon developed different behavioural strategies (Lowe et al. 1994, 1997). The interpretative role of ESA project officers in the ESA implementation process likened to a 'street level bureaucrat' further demonstrates the strategies and interpretations advisers develop to carry out their work (Cooper 1999; Juntti and Potter 2002). These observations suggest that advisers will exhibit some degree of autonomy in providing soil best management practice but within the wider constraints of the AKIS. By incorporating the notion of agency into the AKIS (as shown by Figure 3.4 and Figure 3.1) a better understanding of how advisers can facilitate sustainable soil management can be achieved in this research.

[40] Where actors may be individuals or collectivities (such as government institutions organised in such a way to formulate or carry out decisions) thus taking Long's definition of actors (Long 1992:23 citing Hindless 1986:115).

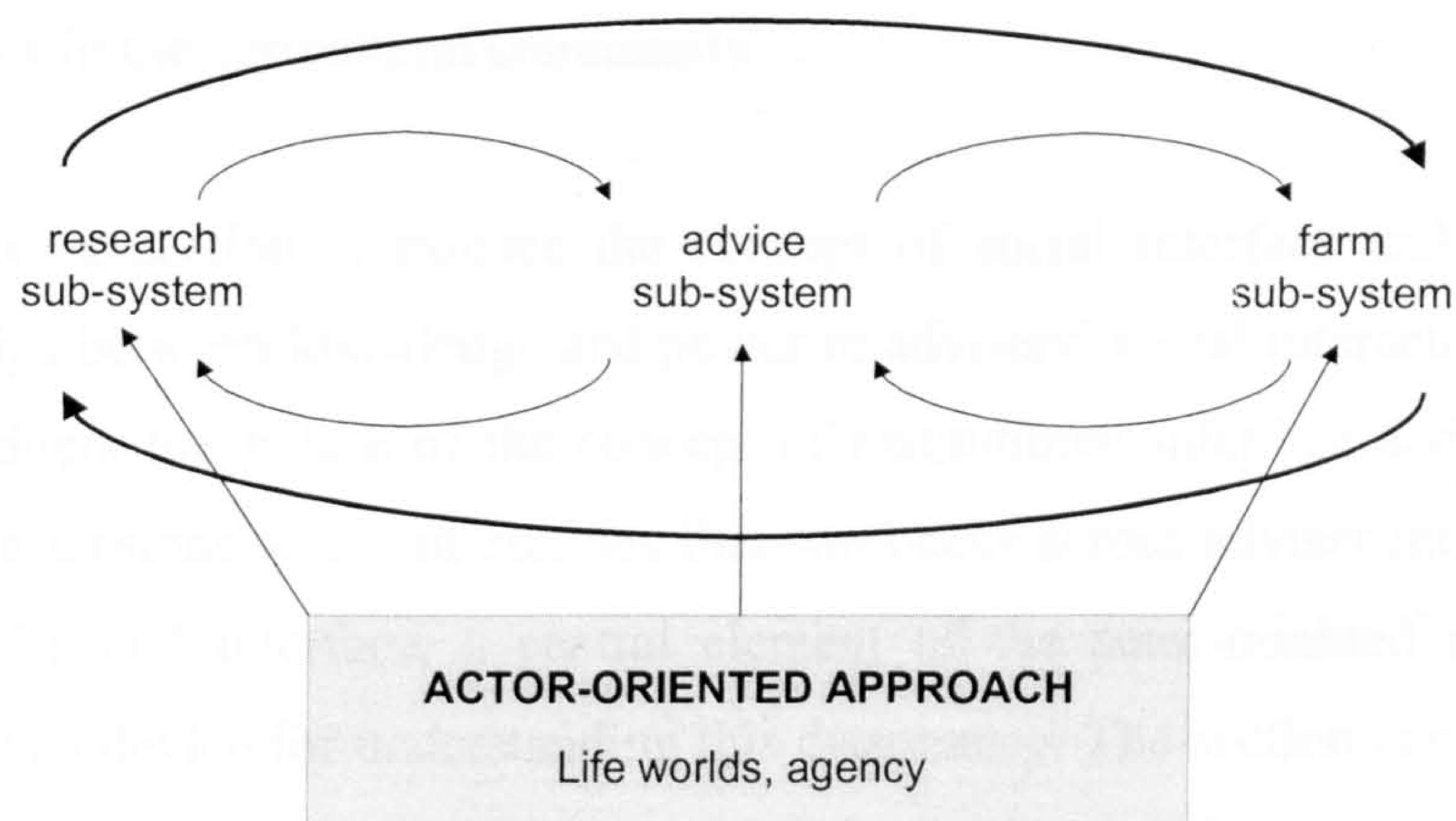


Figure 3.4 Incorporating actor-oriented elements of life world and agency into the Agricultural Knowledge Information System.

In summary by incorporating this actor-oriented understanding of life worlds[41] and agency, a more holistic and inclusive AKIS can be conceptualised as a basis for understanding the knowledge processes advisers engage in within the AKIS in England in the context of soil best management practice. The concept of AKIS can be used to structure the process of enquiry and provide a contextual framework for describing the larger frames of influence that actors must negotiate, while the actor-oriented approach suggests useful analytical perspectives for understanding individual actors' actions and strategies. This combination provides a focus on knowledge processes among actors rather than simply on extension efforts and incorporates a more comprehensive view of human agency than previous linear models by recognising that what people know and what they do are intrinsically related (Roling and Engel 1990). It is well suited to a study of the AKIS in England where advisers operate under the structural constraints of fragmented institutional linkages, regulation, policy and market forces. In particular it accounts for the fact that communicative intervention in agriculture takes place in a diverse and complex multi-actor setting which is increasingly controversial as the traditional actors in the agriculture sector face new pressures from politicians, environmental activists and

[41] The term life world is taken here to be synonymous with social field, cultural paradigm and knowledge culture.

consumers (Leeuwis 1993b). Indeed, Wilson (2001) highlights the relevance of actor perspectives in the transition from productivist to post-productivist agriculture arguing that these perspectives are more suited to the plurality of disparate opinions on issues surrounding the environment, such as sustainable agriculture, demonstrated by all actors in the agricultural community.

The following sections introduce the concept of social interface and discuss the relationships between knowledge and power in advisers' social interactions. Section 3.2.6 considers the failure of the concept of institutional interface and network to explain the tensions and contestations that can occur across adviser interfaces. The concept of social interface, a central element of the actor-oriented approach, is proposed as a device for understanding this dissonance. The section is concluded by proposing the combination of the concepts of institutional and social interface in the development of a new conceptualisation for understanding advisers' knowledge processes in the context of sustainable soil management in England.

3.2.6 Social interface: a central element of actor-oriented understanding

The most common view of the adviser as a link or 'conduit for two way exchange' or key 'intermediary' (Wilson and Hart 2001) between the farming communities and policy, industry or research communities, as conceptualised by the institutional interface, often neglects the tensions and allegiances the advisers encounter. Rogers (1995) exposed the difficulties faced by change agents[42] who have to breach the social and technical chasms between the change agency, their employer and their clients. Change agents, even though they are links in the systems, may be quite 'hetereophilous', that is, different in relation to both their clients and the technical experts. This notion of heterophily relates strongly to culture or life world as described in section 3.2.5 and suggests that advisers, as cultural groups, can differ from groups of farmers and scientists. This gap on both sides can create role conflicts and problems in communication as Rogers (1995:336) observes 'as a bridge between two differing systems the change agent is marginal figure with one foot in each of two worlds'. Evidence from other countries shows that tensions between

[42] Change agent defined as 'an individual who influences clients innovation-decisions in a direction deemed desirable by a change agency' Rogers' (1995:335).

advisers and their employers can arise where the power of decision making for goals and provision of resources is set at the top of the organisation but the execution of extension activities is located at lower levels (Coutts 1995; Campbell 2000). In some instances advisers are known to develop different orientations in approach and function in dealing with clients, usually by favouring or forming an alliance with one side, for example, adviser-farmer alliances (Winter 1995).

Evidence from the UK points to tensions in a number of cases where adviser interactions with farmers are compromised by their association with policy and regulation (Eldon 1988; Seymour et al. 1998b; Whittemore 1998; Cooper 1999). Some commentators have pointed out that state advisers in England, by having to simultaneously serve the Government and the farmer client, are placed in an 'arena of conflict' (Rolls 1998). Changes in policy and regulations can act to undermine advisers' previous advice and therefore their relationship of trust with the farmer. Eldon (1988), for example, suggested that state advice was undermined by policy changes in UK where advice before and after milk quotas was contradictory and was a contributory factor in farmers turning from ADAS advisers to the independent sector. The issue of conflict between adviser and farmer has also arisen where advisers have a dual role of both advising on and regulating waste emissions. Farmers in the UK, for example, mistrust Environment Agency advisers who have to both engage with them and police their activities (Lowe et al. 1994; Seymour et al. 1998b; Kidd et al. 2000; MAFF 2001b). The 'interpretative struggles' or confrontation of different perspectives and knowledges, identified between conservation advisers and farmers is a further example of contestation (Lowe et al. 1994; McHenry 1997).

These observations suggest that providing links between sub systems in the AKIS, even when using face to face advice, does not guarantee true dialogue and understanding because of social, professional and cultural dis-connectedness, discontinuities and tensions between different actors (Waldenstrom 2002). Thus, the institutional interface with its emphasis on linkage mechanisms, fails to encapsulate what is actually occurring.

A crucial aspect of the actor-oriented perspective is an understanding of the processes by which knowledge is negotiated and jointly created through various types of social encounters at what is called the 'social interface' (Long 1989). This would seem a useful device for explaining the dissonance between advisers and other actors in the AKIS. The social interface is conceptualised within the actor-oriented approach as a place of knowledge emergence, conflict, negotiation and linkage. It is defined as 'a critical point of intersection or linkage between different social systems, field or levels of social order where structural discontinuities, based upon differences in normative value and social interest are most likely to be found' (Long 1989:2). Box (1989: 167) understands it more simply as 'sets of interactions and communications between actors involved in different knowledge networks'. Interfaces are thought to contain within them many levels and forms of social linkage and many different and sometimes conflicting forms of knowledge, which intersect and interact. Here the emphasis is on transformation of meaning at the point of intersection between different actors' life worlds. Although this concept was devised to depict the behaviour of actors in intervention situations in developing countries it is relevant to this study as the social interface can equally describe how conflicts and tensions affect the way the knowledge is created, exchanged and utilised as advisers interact with other actors in the context of facilitating sustainable soil management in the AKIS in England.

The concept of social interface encapsulates the situation where shared understandings, needed to achieve knowledge exchange, are absent. Lack of understanding between advisers and farmers due to different life worlds or cultures has been blamed for ineffective advice. Some believe that advisers' limited understanding of the non-material motivations of land users has contributed its share to inappropriate advice (Bergsma 1996, 2000). Shaxson (1997) shares the same concerns suggesting that advisers as 'outsiders' have perceptions and assumptions which are derived from specific contexts of knowledge, culture, training and experience and do not necessarily accord closely with the experience and realities faced by farmers. Long (1992) emphasises that it is in these 'battlefields' of knowledge, through a dynamic process of contestation and assimilation, that innovation and knowledge creation operate.

These observations demonstrate that the institutional interface, a component of the AKIS which emphasises effective linkage, is insufficient on its own to conceptualise the context of advisers' knowledge processes as it fails to explain the negotiations and dissonance that occurs which often prevent true dialogue. However, by combining the concept of social interface with that of the institutional interface a new conceptualisation can be formulated which understands that formal linkages can be subverted by conflicts and tensions thereby providing a more comprehensive view of all the knowledge processes active at adviser interfaces[43]. This combination is represented diagrammatically by Figure 3.5. Given the multiple objectives of advisers concerned with soil best management practice and the tensions brought about by the many pressures they face in terms of policy implementation, environmental regulation and commercial demands, this conceptualisation can provide a more incisive device than using institutional or social interface alone.

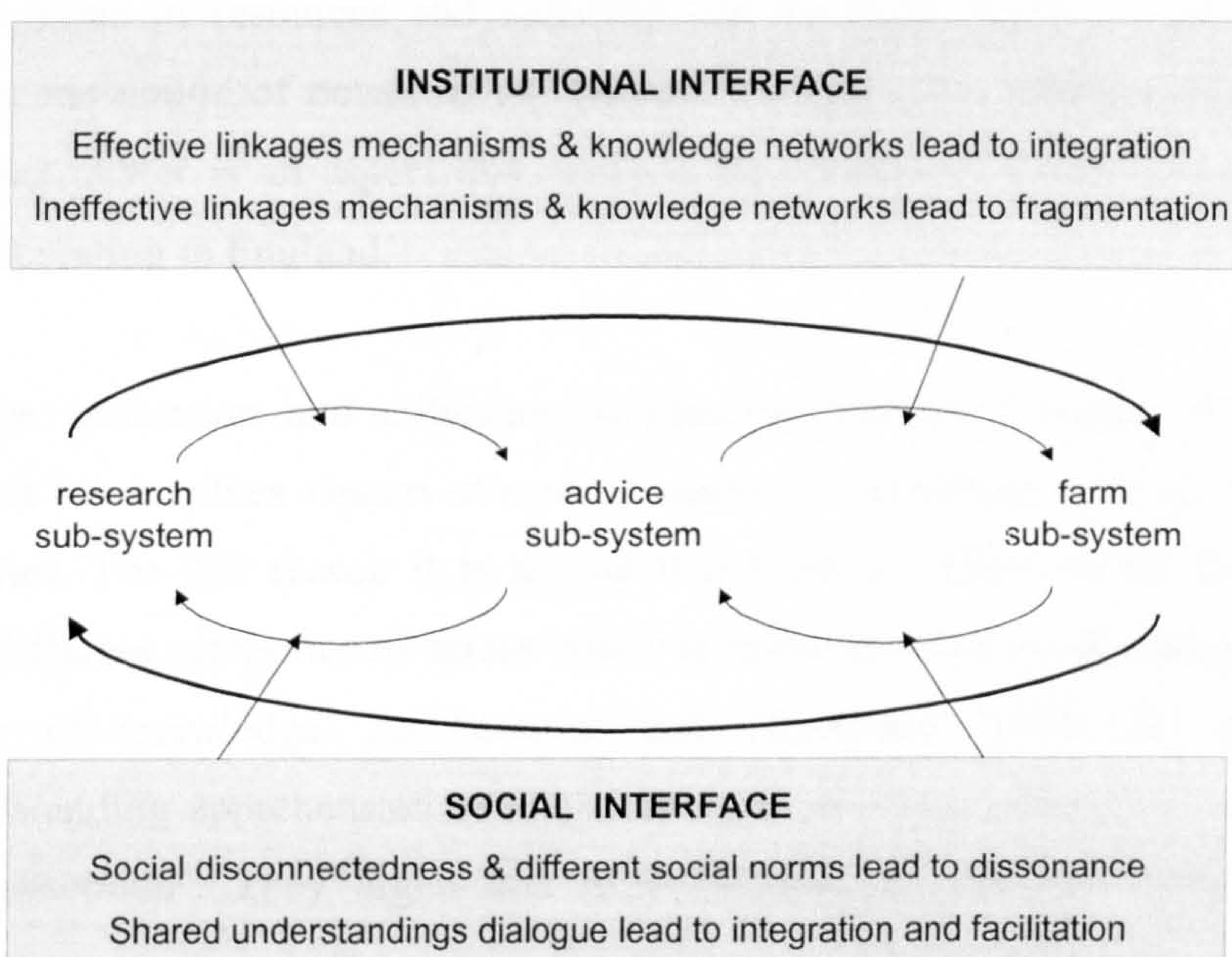


Figure 3.5 Combining the institutional and social interfaces.

Observations of dissonance and negotiations at adviser interfaces highlights the fact that knowledge processes within interface relationships are not uncommitted, as it is here at these 'encounters of horizons' where factors such as trust, power, coercion

[43] This combination also understands that formal linkages can also be reinforced by trust, dialogue and understanding as discussed in section 3.3.5

and tension determine what knowledge is transmitted and how (Long 1989; Ward 1995; Engel 1997; Winter 1997; Morgan and Murdoch 2000). Section 3.3.5 elaborates on aspects of trust and understanding as elements of linkage which counter dissonance at the social interface, the following section discusses the affect of power on knowledge in the context of this study.

3.2.7 Power and knowledge processes

A number of commentators have recognised that an understanding of power dynamics is crucial to knowledge processes within interfaces (Law 1986; Arce and Long 1992; Dissanayake 1992; Scoones and Thompson 1994; Gray et al. 1997). According to Long and Villarreal (1994) power differences and struggles over social meaning are central to an understanding of knowledge processes. Whilst these comments are made referring to interventionist situations where those who hold power in terms of resources and authority can be easily distinguished from the powerless, the notion of power as an 'interest'[44] (Gray et al. 1997) or an influence suggest that power is an aspect that needs to be considered within the context of advisers operating in England.

Knowledge generation and utilisation is seen not just as a matter of technical efficiencies but involves aspects of control, authority and power embedded in social relationships. For this reason it is argued that there are likely to be dissonances between different categories of actors involved in the production, dissemination and utilisation of knowledge. As Scoones and Thompson (1994: 21) point out 'misunderstanding apprehension over hidden agendas and manoeuvres are the rule not the exception'. They argue that it is essential to ask how power affects knowledge, as no knowledge system can exist in a cultural, economic or political vacuum and knowledge of any form must always confront other knowledge systems whether they are those of the government, environment agencies or individuals. This has some relevance to understanding the role advisers play in the exchange of knowledge about soil best management practice, as the outcome of their interactions with different influential actors such as regulators, policy makers, commercial

[44] All parties to the knowledge exchange process according to Gray et al. (1997) have interest in it, where the notion of 'interest' is central to understanding power relations.

employers, project actors, other advisers and farmers, determines what and how knowledge about soil is exchanged.

Traditionally extension is associated with power and intervention; it is a persuasive device to get farmers to do something someone wants them to (Gray et al. 1997). Within the policy implementation process advisers are understood to occupy a powerful and influential position (Jones et al. 1987; van der Ban and Hawkins 1996; Long and van der Ploeg 1989), and this is no exception for England as highlighted in Chapter 2. Traditionally advisers have been conceptualised as 'change agents' defined as 'an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency' (Rogers 1995:335). This concurs with the category of 'missionary' provider, working for public sector bodies in England distinguished by Angel et al. (1997), who have a policy agenda they wish to steer.

A growing reliance on technological advice (itself a function of over-stretched farmers working in a context of diminished markets seeking to optimise profits) represents an aspect of power in relation to conventional agricultural practices (Jones et al. 1987; Ward 1993; Tsouvalis et al. 2000b). Ward (1995) for instance describes agronomists as technical experts who have a powerful and influential role on the farm and are part of the momentum to control and expand pesticide use and maintain the 'chemical paradigm'. Farmers were found to be highly dependent upon advice from technical advisers in decisions about types and doses of pesticides and reluctant to contradict their advice, arguing they did not have the technical expertise to take risks and that chances of compensation, should the pesticide fail, would be jeopardised (Ward and Munton 1992). Such advisers, acting as experts, gain authority from relying on technical and scientific models to defend and define practices (Burgess et al. 2000).

However, with a move away from supply to demand driven advice, professional advisers do not push particular technologies anymore but strive to answer the information needs of the user (Garforth et al. 2003). As commercial advisers become more 'reactive' the farmer themselves arguably should become more powerful in the relationship. Indeed farmers do negotiate or refuse advice and resist intervention (Ward and Munton 1992; Lowe et al. 1994). However, some argue even in this case advisers are influential, and they warn that with specialist farmers advisers work in a 'comfort zone' where they just provide what the farmer wants to know, do not spot any problems or opportunities on the horizon (Angell et al. 1997) and in a sense 'close off' non-chemical options (Ward 1995).

Clearly the power or influence an adviser can bring to the relationship with a farmer is an element that needs to be accommodated in this research. Advisers concerned with soil management will comprise those enforcing regulations, those implementing policy and those involved with sustaining the commercial chemical paradigm that Ward (1995) described. However, given that the majority of soil best management practices are voluntary the power of the farmer must also be considered. By recognising that power can affect knowledge processes will provide further insights in adviser-farmer knowledge interactions and must underpin any conceptualisation of advisers' knowledge processes in the context of sustainable soil management.

3.2.8 An actor-oriented AKIS conceptualisation for adviser interfaces

The discussion presented in this section 3.2 has shown that incorporating the actor-oriented approach into the AKIS allows a more comprehensive understanding of the knowledge processes advisers engage in within the AKIS in England in the context of soil best management practice. In this interpretation knowledge is considered to emerge out of a complex process involving social situation, cultural and institutional factors. In this new conceptualisation the AKIS can be used to structure the process of enquiry and provide a contextual framework while the actor-oriented approach incorporates an understanding of life worlds, agency and social interaction (Figure 3.6). The AKIS for instance describes the larger frames of influence that actors must negotiate, while the actor-oriented approach suggests useful analytical perspectives for understanding individual advisers' actions and strategies thus providing a more comprehensive view of human agency than the AKIS alone. It accepts that advisers concerned with soil can act according to individual strategies and agency but that the AKIS ultimately enables and constrains them.

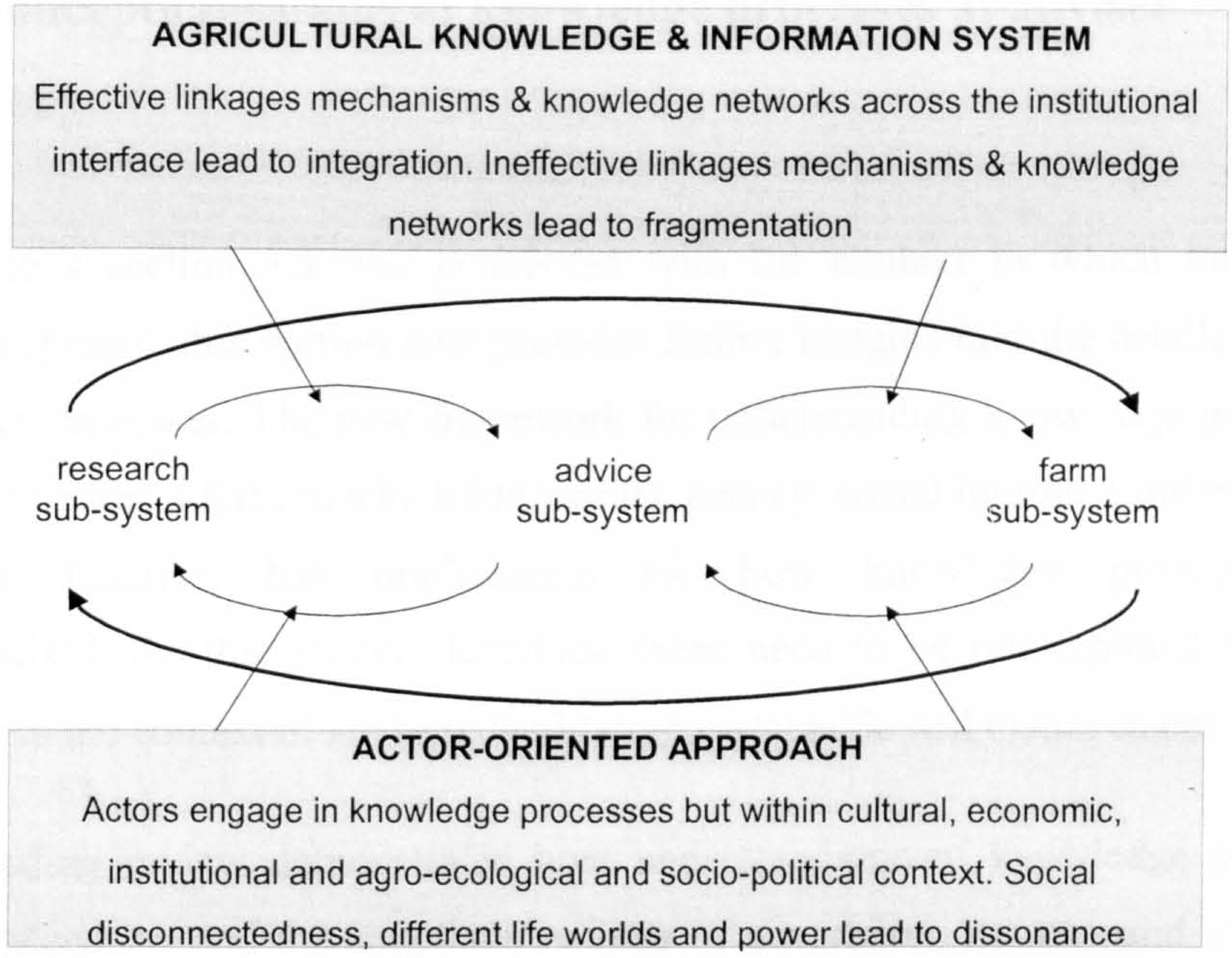


Figure 3.6 A new conceptualisation of adviser knowledge processes.

The notion of interface is considered crucially important in this conceptualisation because it is here at the boundaries between life worlds and institutions where advisers engage in knowledge processes. The AKIS institutional interface, with its emphasis on linkage, provides a framework in which to situate the analysis. However, the actor-oriented social interface understands that knowledge processes across these interfaces are never uncommitted. Aspects of power and influence lead to social dis-connectedness, which explain fragmentation just as much as failed linkage mechanisms. Advisers operate at the boundaries between science and practice and the dual concept of institutional interface and social interface allows an understanding of the linkage mechanisms and networks that connect advisers to other actors but also describes the tensions and aspects of power embedded in these as they try to bridge different cultures and institutions.

A new conceptualisation has been proposed to understand the advisers' role in facilitating sustainable soil management. An application of this new conceptualisation could enable a more complete realisation of the objectives of this research, as set out in Chapter 2.

3.3 Conceptualisations of knowledge processes at adviser interfaces

The previous section 3.2 was concerned with the context in which knowledge processes operate, this section now provides further insights into the details of these knowledge processes. The new framework for understanding knowledge processes, the actor-oriented AKIS, in which life worlds, agency, social interface and power are prominent features, has implications for how knowledge processes are conceptualised. As this section describes, these need to be reinterpreted as social processes in the context of advisers facilitating sustainable soil management.

The preceding review demonstrated how understandings of knowledge processes have advanced beyond the simplistic notions of generation, transfer and utilisation which were described in the early knowledge systems models (Havelock 1986) and the knowledge processes operating across institutional interfaces described by Roling (1988) in his definition of the AKIS as generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation, as shown in Figure 3.7.

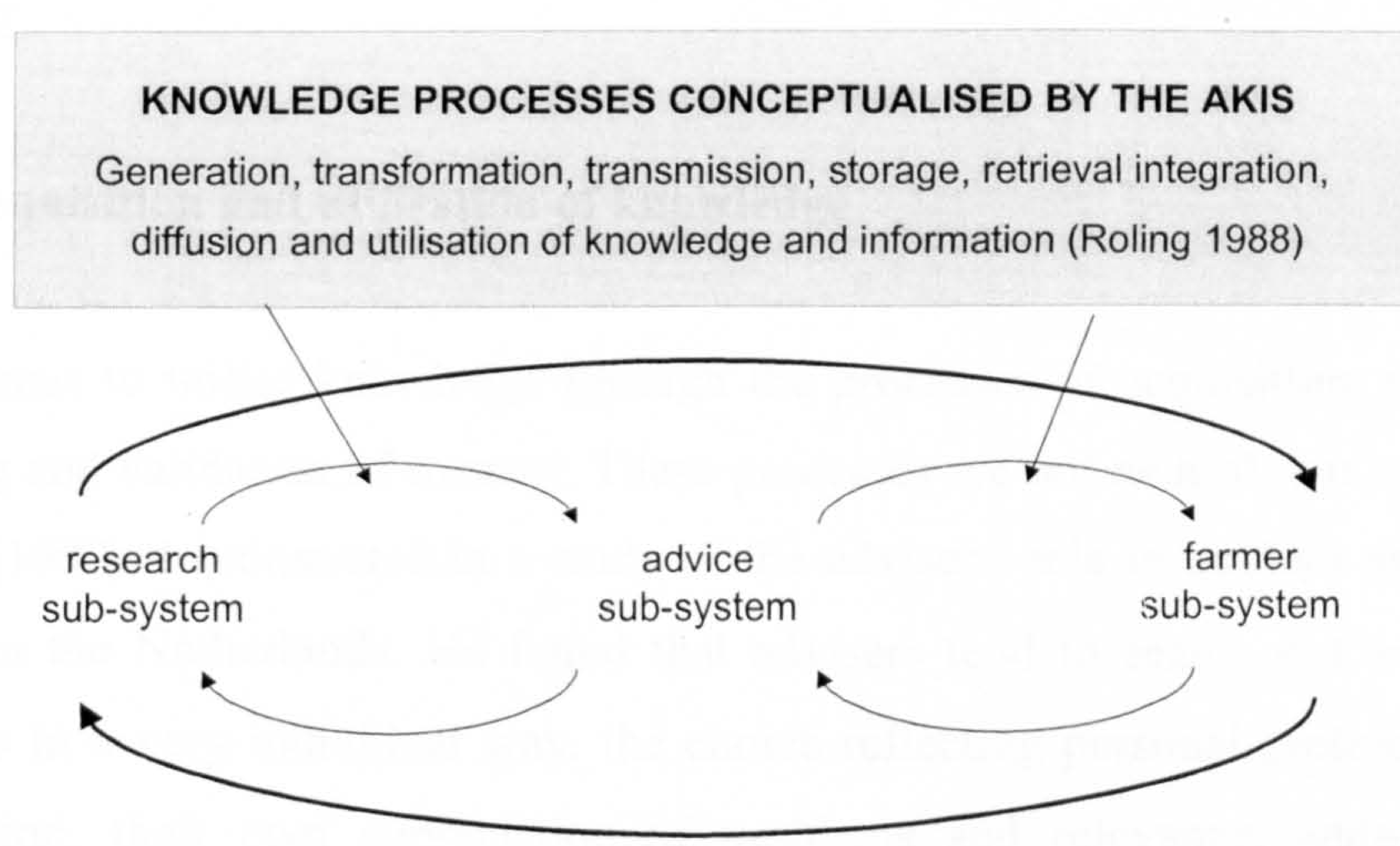


Figure 3.7 Knowledge processes as defined by Roling (1988) operating across institutional interfaces in the AKIS.

Constructionist views, which underpin the actor-oriented approach, can be used to understand and reinterpret these knowledge processes. Rather than discrete processes, which suggest communication of knowledge as a commodity, these can be reinterpreted as continuous and interchangeable (Long and Villarreal 1994). They are thought to imply several interconnected elements, namely: actor strategies and capacities for drawing on existing knowledge and absorbing new information through validation, reception and verification and re-creation where new information and its sources are judged as acceptable/useful or are contested (Long and Villarreal 1994; Portela 1994). Most importantly the production, consumption and transformation of knowledge is seen to lie in the processes by which social actors interact, negotiate and accommodate each others' life worlds, leading to reinforcement or transformation of existing types of knowledge or the emergence of new forms (Long 1989). The implications of this interpretation for understanding how advisers concerned with soil in the AKIS in England engage with knowledge will be discussed in the following sections, which focus respectively on acquisition and utilisation, transformation and integration of knowledge. Although these are dealt with separately, in reality these processes are indistinguishable as they are operate simultaneously. Figure 3.1, repeated below, shows how development in the conceptualisation of knowledge processes fits into the framework elaborated in section 3.2.

3.3.1 Acquisition and utilisation of knowledge

Advisers start to utilise knowledge through the processes of acquisition, selection, processing and validation of sources. These processes are not neutral, but subjective as Engel (1997) demonstrated in a study of the advisers' role in outdoor storage of manures in the Netherlands. He found that advisers tend to search out and value documents in a very individual way, the choice reflecting personal preference and specialisation, their own appreciation of problems and relevance, added value, suitability, and ease of use for farmers. Here the adviser has not only interpreted the information but also pre-selected what he feels the farmers need to know. In England advisers must select their soil management information from a huge range of policy, NGO, trade and scientific material as highlighted in Chapter 2.

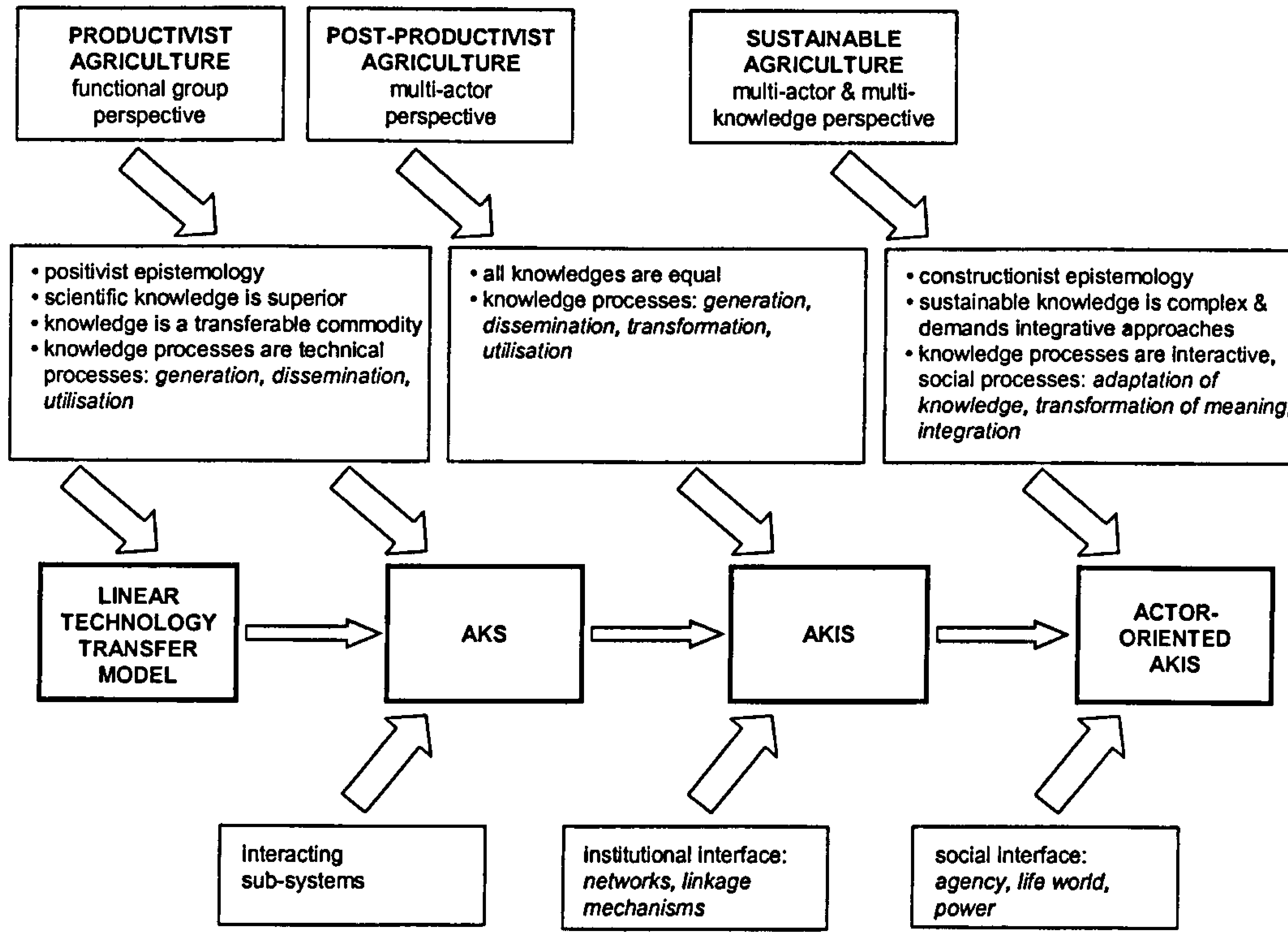


Figure 3.1 (repeated) Developing an actor-orientated AKIS conceptualisation.

The difficulties of accessing scientific knowledge have been discussed by Wynne (1991) who talks of the 'sheer effort' needed to monitor sources of scientific information, judge between them, keep up with shifting opinion and decide how to 'qualify' expert knowledge for their particular situation and what level of knowledge is 'good enough' for them; this is not necessarily the same level as the scientists have assumed, the threshold may be looser or tighter. Advisers concerned with soil arguably go through the same processes when evaluating, selecting and judging the efficacy of knowledge for use on farm. The implication for this research is that advisers develop their own acquisition and selection strategies in accessing information about soil from the plethora of sources in the AKIS in England.

Earlier knowledge systems perspectives saw utilisation as restricted to farmers only but it is now believed that all actors, including advisers, utilise knowledge generated in other parts of the system. Utilisation is also understood as a more subtle, continuous process than the earlier simplistic notions of 'adoption' and thought to be intimately bound up with knowledge transformation, integration and creation. The actor-oriented approach contends that actors use knowledge to create and utilise behavioural options, depending on their perceptions, resources and strategies (Long 1992; Long and van der Ploeg 1994). People are thought to use knowledge to operate in the real world, by building theories that attribute causes to effects and applying these to control the environment; if things do not turn out as predicted they adapt their knowledge (Roling and Engel 1991). This relationship between knowledge and adaptation was noted by Plotkin (1964), who argued that the human capacity to gain and impart knowledge is itself an adaptation and adaptations are themselves knowledges. In the same way Roling and Engel (1991) view knowledge utilisation as a mechanism for survival, envisaging utilisation as a set of processes occurring across an interface between knowledge and reality which include feedback, inference, perception, reification, attribution, reality testing and communication. Evidence has shown that agri-environmental scheme advisers adapt and use their knowledge to create different strategies and interpretations (Engel 1997; Cooper 1999; Juntti and Potter 2000). Advisers concerned with soil will undoubtedly utilise knowledge in the same way particularly as they need to interpret and adapt the specialised and complex best management practices for specific farm soil conditions.

3.3.2 Transformation of knowledge

Defined by the AKIS perspective (Roling 1990) as a process whereby information generated in one part of the system is turned into information for use in another part, transformation is perceived as being the most crucial process in the AKIS, particularly at the interface between science and practice where the adviser concerned with soil operates. The actor-oriented AKIS approach allows an understanding that information is given different meanings and interpretations by different actors as it become internalised into knowledge and that technologies become transformed through a series of adaptations and evaluations.

Knowledge cannot be transmitted directly, unless transformed or encoded in texts or in language (Roling 1990; Engel 1997). As Roling (1990) states 'meanings are in people' they can be encoded in messages by the source but these messages must in turn be decoded by the receiver (Berlo 1960; Roling 1990; Blum 1991). This decoding relates to the context in which data, information or language[45] are received and to the person who receives it, the outcome of which determines the significance or the meaning given to the information (Ramkumar and Rolls 1995)[46]. Part of this re-coding inevitably involves simplification. Advisers concerned with soil have to assign new meanings to, or decode, soil best management information they receive which has been previously encoded by other AKIS actors through, for example, publications, training or workshops. Advisers then in turn re-code or transform the meaning again before presenting it to farmers as advice. Thus advisers are central to the process of knowledge transformation and understanding this must be a key component of any conceptualisation of advisers and how they process knowledge about soil. The tensions and inevitable compromises and approximations made by those representing complex scientific knowledge to a user-community have also been noted in some studies (Shackley and Wynne 1995).

Transformation can include a range of processes from the technical transformation of information into practice and knowledge through a series of evaluations and adaptations, or as Blum (1991: 322) describes it 'integrating into the original information further results of experimentation and experience by a series of people'. Earlier views of transmitting knowledge as if it were a commodity neglected the vital tasks of transformation, in which technologies were modified by different users and ultimately reinvented as they were incorporated into production systems through the activities of choosing, experimenting and adapting (Rogers 1983; Garforth and Usher 1997) and interpreting, evaluating, reformulating (Ramkumar and Rolls 1995) as part of a continuous process engaged in by both advisers and farmers

[45] Busch (1978) notes the importance of language as new meanings arise in the course of conversations.

[46] Although important as contributing to knowledge, information is not considered to be synonymous with knowledge. Information is described as explicit, visible, touchable, hearable and thus transferable, and defined as a pattern imposed on a carrier such as sound or paper (Ramkumar and Rolls 1995). This implies that people will understand such patterns and attribute meaning to them and through this process turn the information into knowledge, thus a body of information meaningfully stored within the individuals memory is defined as knowledge (Wilson 1987). Leeuwis et al (1990: 20), however, consider it unhelpful to dichotomise the two as 'both are in fact elements of a single interpretative process, since information has no meaning if it cannot be internalised and by being internalised it become part of a stock of knowledge'. Even though he argues it is unavoidable to talk of data, information, models etc. he regards these as 'knowledge constructs of various levels of complexity and concreteness (Leeuwis 1993a: 59). However, for the purposes of this study it is helpful to maintain the AKIS's distinction since the devices DEFRA use such as the Soil Code constitute information as they exist as tangible items, even though different meanings can be attributed to them (Engel 1997).

(Coughenour 2003). This notion of continuous transformation has been described as a stepwise change from science to practice (Lionberger and Chang 1970) or as an iterative process in which chains of product transformations (Engel 1997) or transformation cycles (Blum 1991) occur in continuous circulation.

It is argued, however, that for sustainable knowledge this notion of science to practice transformation is thought to only provide partial insights, which have to be intercepted, interpreted and refined at a local level, a process during which new knowledge is created (Leeuwis 2000). However, these criticisms can be refuted by understanding that transformation involves actors engaging in the processes of learning, reflection, evaluating, experimenting and formulating and carrying out decisions as knowing and active agents (Engel 1997). Researchers, advisers and farmers concerned with soil, at each stage in the cycle will strategise, formulate and construct their own view informed by experience, social negotiation and interaction.

This idea of continuous and iterative transformation involving reflection, evaluation and experimentation is suited to the fine-tuning required for implementing best management practices for soil where researchers, advisers and farmers continuously refine and adapt practices to suit different circumstances. In particular it recognises that advisers and farmers are active in this transformation process by incorporating their own observations and experience.

3.3.3 Knowledge integration

Intimately linked with utilisation and transformation is the process of integration. This blending, synthesis and assimilation of knowledge from different sources is thought to be carried out by all AKIS actors (Roling 1990; Engel 1997). Such integration is enabled through knowledge sharing or exchange. Advisers are considered to have a key role in integration through bringing together knowledge from science and from practice. Through synthesis and interpretation they assess how a policy, technology or scientific knowledge may be integrated within the context of the farmers' own business and environment, an activity that is greatly valued by farmers (Jones et al. 1987; Angell et al. 1997; Engel 1997). Advisers are though to assimilate scientific information into their own knowledge and then impart this technical information to farmers who in turn assimilate, re-create and integrate it further (Papy 1994; Portela 1994). Integration also involves the advisers' assimilation of knowledge generated by farmers. For example, observing agronomists and farmers in East Anglia, Lyon (1996) found that agronomists, through comparing many farms with the same treatment, brought together and integrated this locally derived knowledge with their own technical understanding.

Integrating, merging and blending of knowledge from scientific and practical sources is thought to be vitally important in striving to achieve sustainable agriculture (Arce and Long 1992; Murdoch and Clark 1994; Clarke and Murdoch 1997; Morgan and Murdoch 2000). However, the tensions at the interface between science and practice, as described in section 3.2.8, make integration a challenging process for advisers. As Scoones and Thompson (1994) argue, assumptions that knowledge generated by science can be integrated or blended seamlessly into farmer practices are flawed since these knowledges are both manifold, discontinuous and dispersed. Others, however, argue that knowledges derived from farmers and from science are complementary and supplemental and not in conflict (Molnar et al. 1992), and the fact that new ideas and technologies are continuously absorbed and reworked through creativity and experimentation is testament to the fact that integration does occur (Long and van der Ploeg 1994). It could therefore be argued that advisers are already helping to reconcile the different realities in which farmers and scientists operate by facilitating this integration. Figure 3.8 represents these revised interpretations of knowledge processes active at adviser interfaces.

Advisers' informal relationships at interfaces and networks are thought to play 'a pivotal role' in maintaining continuous transformation and integration of knowledge (Engel 1997: 370). As Hatcheul (1997) notes knowledge and relationships become inseparable. Given this, and the fact that knowledge integration is a central process in which advisers are involved, the following sections discuss how this integration can be enabled through advisers' social interaction with other AKIS actors. Firstly the importance of advisers sharing knowledge through networking, and the contribution this makes to knowledge integration, is considered. Secondly, and more specifically, the significance of facilitation of knowledge integration through strong adviser-farmer relationships is discussed.

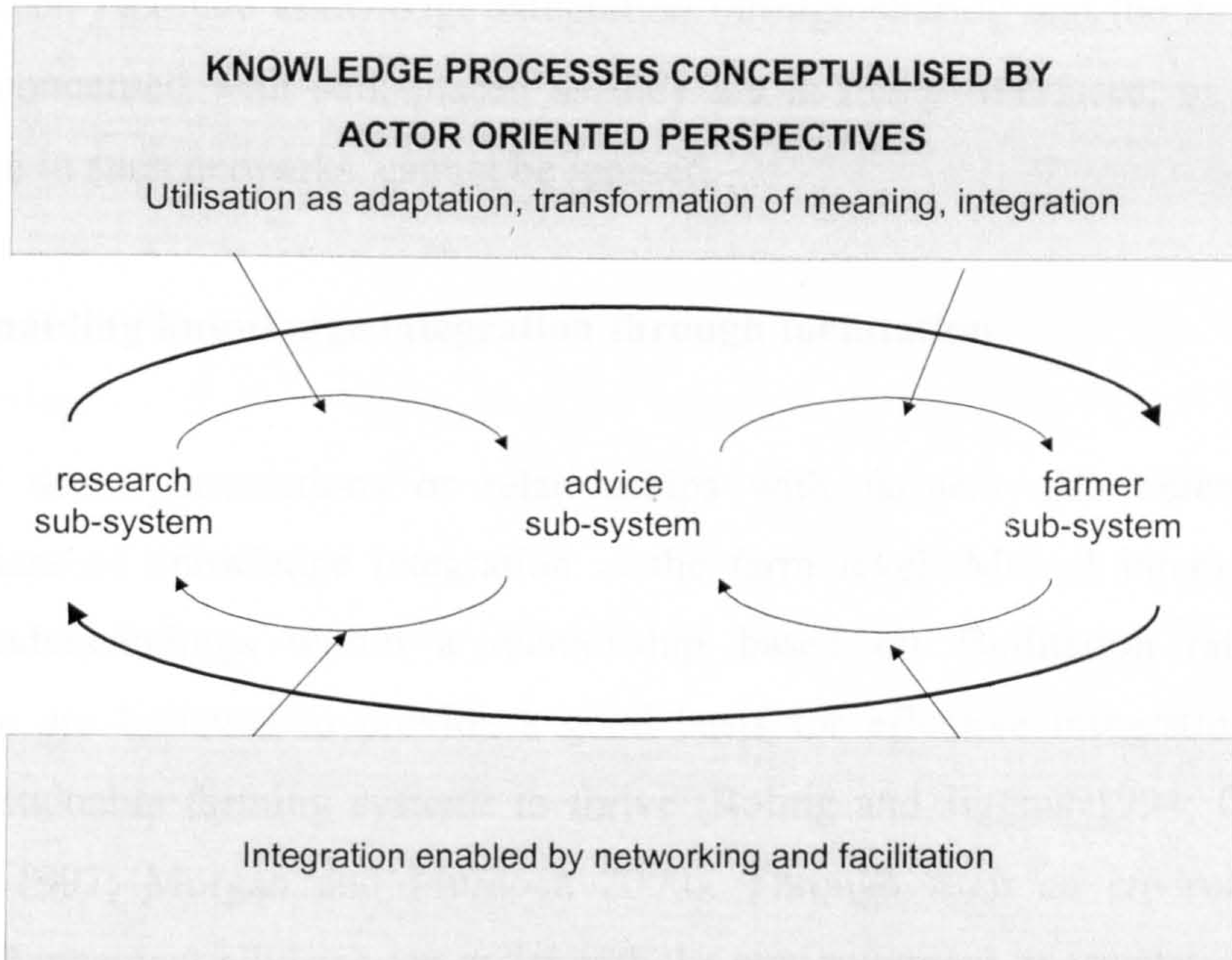


Figure 3.8 Actor-oriented interpretations of knowledge processes at adviser interfaces.

3.3.4 Enabling knowledge integration through networking

The importance of networks in linking actors and institutions was discussed in section 3.2.2. The potential contribution of these multiple informal connections towards achieving sustainable agriculture has also been highlighted (Engel 1997; Morgan and Murdoch 2000). The value of networks as social entities in enabling the integration of knowledge and the role advisers play in contributing to networks cannot be overlooked. Box (1989: 167) stresses the social element of networks when defining a knowledge system as 'a model we have in our heads regarding knowledge exchanges through social networks in a particular realm of human activity'. Thus networks operate within or across organisations where actors actively build and maintain relationships with those they appreciate as being relevant to their concerns and within these networks they generate, share and use knowledge (Engel 1997). He goes on to talk of networks as 'embedded in long standing social relationships in which mutual understandings and trust are essential to facilitate knowledge sharing' (Engel 1997:37). Within the networking tradition two-way communication and support, interdependencies, synergies, trust and complementarities among actors are emphasised (Warriner and Moul 1992; Clark and Murdoch 1997). Thus these networks can facilitate knowledge integration through sharing and the key role for advisers concerned with soil, placed as they are at many interfaces, or points of connection in such networks, cannot be ignored.

3.3.5 Enabling knowledge integration through facilitation

Advisers' social interactions or relationships with farmers also determine the effectiveness of knowledge integration at the farm level. Mutual interaction and shared understandings within a relationship based on facilitation rather than instruction are believed to provide a good basis for effective integration and so enable sustainable farming systems to thrive (Roling and Jiggins 1994; Clark and Murdoch 1997; Morgan and Murdoch 2000). Through such an environment of mutual enhancement advisers can assist with the empowerment, reorientation and re-skilling of farmers that many consider essential to managing complex systems and achieving new practices and outlooks in farming (Roling and Jiggins 1994; Curry 1997; Morgan and Murdoch 2000). Personal interaction in a context of shared experiences is also thought to be the only way to communicate locally derived or tacit forms of knowledge considered by some to be so important for sustainable agriculture (Hassenein and Kloppenburg 1995; Morgan and Murdoch 2000). The nature of the adviser-farmer relationship becomes particularly important in achieving this facilitation.

It is acknowledged that an adviser needs to establish an information-exchange relationship and develop a rapport with the farmer by showing that he is reliable, competent, credible, and above all trustworthy and can empathise with clients' needs and problems (Chambers 1993; Gasson and Hill 1996; Juntti and Potter 2000). Impartial and trusted advice from a credible source has been found to be crucial for gaining farmer confidence whether in a commercial or extension situation (Eldon 1988; Contant 1990; AERDD 1996). Some emphasise that this has to be mutual two-way trust (Dudal 1981; Bergsma 1996). Many agree that if the credibility of the adviser is compromised the message itself is lost. As Rogers (1995) comments, the client must accept the change agent before they accept their message[47].

[47] Rogers (1995) distinguishes between 'competence credibility', the degree to which a communication source or channel is perceived as knowledgeable and expert and 'safety credibility',

The importance of mutual understanding and 'sincere interest' in the well being of clients are highlighted as central to advisers engaging with their farmers (Ison and Russell 2000; Sheath and Webby 2000). Indeed, Rogers (1995) describes the contact between a change agent and client through 'communication' as the process in which participants create and share information with one another in order to reach a mutual understanding. Empathy is thought to be important in securing this, where it is defined as 'the degree to which an individual can put himself into the role of another person' (Rogers 1995: 342) and extension officers have always been urged to view the situation from the client's perspective in the diagnosis of problems (van der Ban and Hawkins 1996); although as Busch (1978) notes, this is inherently difficult.

Some of the keys to arrive at this good understanding of others and looking at other perspectives are: listening and learning, taking a keen interest, joining in activities and patience and dialogue (Busch 1978; Engel 1997; Kersten and Ison 1998; Bergsma 2000; Kersten 2000; Waldenstrom 2002). Some stress the importance of these processes for advisers, Rogers (1995) for instance believes that 'social expertness' rather than technical expertise may be one of the most important qualities an adviser has, as client-oriented change agents will more likely be feedback minded and to have a closer rapport with their clients. Leeuwis (2000) introduces the idea of a 'social agronomist' to describe the same idea.

Possessing an intimate knowledge of farming practices is thought a key factor in advisers' ability to place themselves in the 'shoes of the farmer' (Dalton 1980). The need for advisers to respect farmers autonomous decision making powers is not new; in doing so Giles (1983:324) asserts that on-farm advisers may personally gain enriched experience and knowledge 'by listening and talking to those in the industry who accept the risks and take decisions'. van Crowder and Anderson (1997) reinforce this view, talking of the advisers' reorientation and improvement needed in communication skills and professional attitudes to enable them to recognise the importance of farmers' experimental insights and technical adaptations. Some point out that good communication and relationships do not just happen, they need to be

the degree to which a communication source is deemed trustworthy and argues that an ideal change agent would have a balance between the two.

managed (Engel 1990; Gasson and Hill 1996; Lundberg 1997). Examples of advisers cultivating trusting and loyal relationships are given by Ward (1995), while Hawkins (1991) found that much effort was spent by technical advisers trying to convince farmers of the coincidence of interests between farmers and company.

Rogers (1995) makes a link between empathy and group cultures (or life worlds), as defined in section 3.2.5. He considers that communication between advisers and farmers is more effective where individuals are similar (homophilous), and that adviser-farmer heterophily (where individuals differ) in technical competence and subculture, language, socio-economic status, beliefs and attitudes is the worst situation for exchange and engagement and leads to misunderstanding. Thus, the tensions at the social interface, which inhibit knowledge integration, can arise out of lack of understanding between different cultural groups.

This shared understanding, genuine or managed, reinforces relationships and knowledge exchange. The context of social interaction at the adviser-farmer interface is therefore considered crucial in influencing knowledge processes most importantly in determining the effectiveness of knowledge integration in the context of soil best management practice. This discussion puts a new perspective on the social interface, revealing it as a place, not only of dissonance, but also of mutual understanding and linkage, as was intended by Long (1989). This is captured by Figure 3.5.

Delineation of the processes of utilisation, transformation, integration, and the processes that enable integration, provide a suitable means of understanding the processes which advisers engage in at the interface between science and practice in the context of soil best management practice. The AKIS provides a framework in which these knowledge processes are enabled and/or constrained. The actor-oriented perspective allows us to understand that these processes of knowledge exchange are never uncommitted, they are embedded in social processes and as such are subject to individual actors' strategies, negotiation, conflict and understanding.

3.4 Conclusion and chapter summary

This chapter has discussed the conceptual basis for the research. Section 3.1 provided a brief overview of how perspectives about knowledge and knowledge processes have developed within a range of relevant literatures in response to a changing agricultural context. Section 3.2 developed a new conceptualisation of the framework for understanding knowledge processes by incorporating constructionist actor-oriented approaches, with the integral elements of life worlds, agency and social interface and power, into the AKIS. Given this new framework, section 3.3 reinterpreted the knowledge processes as conceptualised in the AKIS as continuous, interchangeable processes involving the utilisation through the adaptation of knowledge, the transformation of meaning, and the integration of knowledge. The sharing of knowledge through social interactive processes of networking and facilitation, which enable integration, were considered particularly relevant to the advisers' role at the interface between different institutions and between advisers and farmers. Together these provide a new interpretation of knowledge processes that advisers engage in, in the context of soil best management practice in the AKIS in England.

The actor-oriented AKIS approach offers an epistemological and methodological framework with wide conceptual boundaries that places the analysis of soil best management practice within both a micro (individual actor) and macro (AKIS framework) context. It provides a more sophisticated conceptualisation of individuals based on an understanding of knowing rather than knowledge, competent performance rather than use of new technology and communicative interaction rather than communication as transfer of messages, thus incorporating the social dimensions of knowledge processes. Taking an actor-oriented perspective within the context of the AKIS framework provides an appropriate means of understanding knowledges processes in the context of soil best management practice in the AKIS in England. The AKIS framework allows identification of the structural constraints to knowledge exchange in terms of (in)effective linkage mechanisms, institutional interfaces, competition between advice providers, policy and regulation, and environment and consumer pressures, all of which affect advisers concerned with soil in the AKIS in England, as discussed in Chapter 2.

The actor-oriented approach provides insights into how actors, specifically advisers in soil best management practice, negotiate knowledge within this framework. It portrays them not as neutral disseminators but as knowing and active individuals who must negotiate knowledge at the interface between different life worlds and institutions. In understanding the role of advisers in facilitating sustainable soil management, we therefore must look beyond them as providers but understand that they acquire, utilise and adapt knowledge and transform knowledge subjectively. Most significantly this approach understands that advisers are central to integrating knowledge through social interaction. Advisers' social relationships with all actors in the AKIS, but specifically with farmers, are therefore central to an understanding of how they can facilitate sustainable soil management.

Chapter 4

METHODOLOGY

4.1 Introduction

Chapter 3 concluded that the actor-oriented AKIS provided the most appropriate conceptual framework for analysis of knowledge processes at adviser interfaces. This chapter provides a justification for, and details of, the methodological process by which quantitative and qualitative information was collected in order to realise the key research objectives, namely:

- to provide detailed empirical evidence of the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about soil best management practice;
- to elicit the factors that enable and constrain these knowledge processes;
- to make a contribution to the conceptualisation of Agricultural Knowledge Systems surrounding sustainable soil management in England; and
- to make policy relevant suggestions for improving the operation of the Agricultural Knowledge System in order to achieve more sustainable soil management.

To address these objectives in the context of the conceptual framework a methodology is needed that can:

- provide empirical evidence which allows the knowledge processes to be identified and characterised;
- examine how the AKIS enables and constrains knowledge processes at the advisers' institutional interfaces; and
- examine how these knowledge processes are affected by the AKIS actors' differential adaptations or responses to the same circumstances within the AKIS.

The combination of quantitative and qualitative methods of data collection and analysis offers a valid form of inquiry that can meet these requirements. As such this study employs respectively, an extensive postal questionnaire survey of a range of agricultural advisers and three detailed case studies: the UK Soil Management Initiative (SMI); the Landcare Project; and the SUNDIAL Fertiliser Recommendation System (SUNDIAL-FRS). The extensive survey is large scale and contextual and complements the more illustrative and intensive case studies. The exploratory survey opens up questions about patterns in the relationships between advisers and other AKS actors while the qualitative techniques of the case studies allow the processes underpinning these patterns to be elucidated.

The quantitative methods used in the survey can be used to address the first research objective by providing empirical evidence of the role that agricultural advisers play in knowledge processes by identifying broad patterns of knowledge acquisition, utilisation, generation and transfer. In addition the survey enables description of advisers' institutional structures, linkage mechanisms, interfaces and networks, giving some insight into the factors that might enable and constrain these knowledge processes, thereby addressing the second research objective.

Case studies use qualitative methods which seek to understand and explain processes and are more appropriate for investigating individual advisers as they interact with other actors at social and institutional interfaces. As such they provide further insights into the role agricultural advisers play in knowledge acquisition, utilisation, generation and transfer of knowledge and how they devise ways of surmounting and negotiating enabling and constraining factors.

Quantitative methods of questionnaires are underpinned by positivist traditions which seek to explain phenomena by measuring facts while qualitative methods of the case study focus on peoples' understanding and interpretations of their social environment. Combining them fuses the twin aims of 'how' (understanding) and 'why' (explanation) in social research, and as such is consistent with the principles of the actor-oriented AKIS. This combination of methods not only enables different questions to be addressed but offers the possibility of triangulation, that is, using multiple methods or different sources to compensate for bias or lack of validity of any one, to maximise understanding of the research questions and to ensure confirmation and completeness (Denzin 1970; Parfitt 1997; Arksey and Knight 1999). Different methods may also elicit different responses and using a mix of methods allows cross checking of any contradictory responses.

4.2 The adviser questionnaire

The postal questionnaire has been adopted by many researchers aiming to analyse a large, spatially heterogeneous population. Specifically, use of a questionnaire suited the aim of building up a profile of the agricultural adviser community in England, as this relates to soil best management practice, in terms of their background, the organisations they work for, how they exchange knowledge about soil management, the linkage mechanisms they use, the networks in which they operate and the interfaces they encounter in the AKIS. In the context of this research it provided the easiest, most cost effective methodological tool with which to reach a large population of agricultural advisers given the limits on time and money.

Quantitative methods like questionnaires assume a particular view of the social world as something that can be objectively measured. Questionnaire surveys have their origins in the positivistic tradition where the concern is for measurement and standardisation. They try to represent and simplify a complex social world by collecting and assembling data from which generalisations and explanations can be made about human behaviour. Such an approach understands that there are 'facts' which can be gathered about the social world which exist independently of how people interpret them (May 1997:10).

Methodological problems associated with structured and postal questionnaires have been explored by a number of commentators (May 1997; Parfitt 1997). It is thought that researcher presuppositions lead to particular questions to be asked and can restrict the way people reply. As May (1997:104) notes 'the myriads of differences in people's attitudes and the meanings which they confer on events can hardly be accommodated by compartmentalising them into fixed categories (closed questions) at one point in time (the actual completion of the questionnaire)'. The main disadvantages of postal survey, as opposed to telephone and personal interviews, include lack of opportunity to: clarify questions, explore certain aspects of answers, control the order in which questions are answered, study the respondents as they answer, introduce informal validity checks, and prevent respondents from consulting other sources. Postal questionnaires, however, have the advantage of standardised delivery, with no bias introduced by the interviewer reading the questions; they are also visual and allow all the response categories to be seen before a choice is made. In this research the respondents were a professional community and there was no concern about literacy skills and understanding of the questionnaire. Response rates are also thought to be higher from surveys of professional groups particularly when the topic of investigation is of relevance to them, previous studies of advisers have demonstrated this (Cooper 1999). Concerns about questionnaire clarity can also be addressed by making it simple, and carefully structured to make up for the fact that no interviewer is present to explain the questions (Glastonbury and Mackean 1991). Furthermore, many of the concerns about postal questionnaires, highlighted above, are addressed in the qualitative phase of the research.

4.2.1 Questionnaire sampling

A questionnaire survey is 'a method of gathering information from a number of individuals, a 'sample', in order to learn something about the larger population from which the sample is drawn' (Ferber et al. 1980 quoted in May 1997: 85). It is therefore very important that the sample characteristics are the same as those of the population. The agricultural advisory community in England is diverse and numerous and includes specialists in a range of areas such as agronomy, crop protection, livestock, marketing, business, waste management, drainage, machinery and conservation, many of whom have no influence on farm soil management decisions. Initially it was therefore necessary to identify a target population, which in this survey is all agricultural advisers in England whose advice might have some impact on soil management decisions on the farm. There are, however, difficulties in identifying these advisers, as they are not a discrete, easily accessible population. While a few advisers may be specialists in soil, most will be generalists who influence soil management decisions through a wider programme of advice on agronomy, conservation, regulation, pollution prevention or ERDP schemes. To add to this complexity some advisers will combine other objectives with their advisory roles such as research activities or fertiliser sales.

Agricultural advisers who potentially have some impact on soil management decisions in England were identified by synthesising information from a number of recent reviews of advice provision in the environmental protection and conservation communities (see Appendix 2). This enabled the key organisations and their respective advisers to be identified (see Table 4.1) and these provide the sampling frame for the study, that is a list of sampling units, the elements of interest for a survey, in this case advisers. However, whilst the advisers can be identified within FWAG, the National Trust (NT), the Organic Advisory Service (OAS), and associations for consultants (AICC and BIAC), there is limited information for relevant advisers within ADAS, DEFRA RDS and for agronomists within the commercial sector.

How sampling is undertaken in any particular survey is determined to a large extent by what is available in the way of a sampling frame. In this case the sampling frame is incomplete, with full details available for advisers in some organisations and not for others. For this reason a different approach was taken for each organisation. For FWAG, NT and OAS, which are relatively small organisations, all the advisers were easy to identify and access, and have common responsibilities; consequently it was possible to send questionnaires to all the advisers in these organisations.

However, for other larger organisations where advisers are less uniform and information about them is limited, sampling was necessary to identify advisers relevant to this study, i.e. those who would be representative of the target population. Given the difficulty in identifying applicable advisers within these organisations, probability sampling, in which every member of the target population has a known, non-zero probability of being included in the sample, was not possible. Instead non-probability sampling was used where some members of the eligible population have a chance of being chosen for participation and others do not (Fink 1995).

Relevant advisers in ADAS and DEFRA RDS were hard to identify and access as these are extensive organisations and their advisers engage in diverse activities.

ADAS employs a large range of agricultural consultants as well as advisers providing public good advice, who to complicate things further, also engage in research (see Appendix 3). DEFRA RDS is similarly staffed with a large number of advisers involved in some way in administering and advising on a diverse range of ERDP schemes. To address these difficulties it was decided to send questionnaires to selected regional managers to distribute to all staff they considered relevant within their region. Clearly this introduced some element of subjectivity, however, there was some confidence that regional officer managers were the best informed about their staff's professional responsibilities.

Identifying agronomists (independent and trade) representative of the target population was equally difficult as these are a diverse collection of advisers providing a range of advice from crop protection, crop variety, seed advice and sales through to whole farm agronomy. In this case the FACTS register of agronomists was used. FACTS (Fertiliser Advisers Certification and Training Scheme) is an accreditation scheme run by BASIS[48] which assures training in fertiliser practices and has a large number of advisers registered from many organisations. These will inevitably include advisers outside the target population but represented the only option available. Using FACTS provides a second opportunity for including ADAS, RDS, FWAG advisers who register. The FACTS organisation agreed to attach the questionnaire and an accompanying letter to an emailing going out to a set of 700 advisers registered. However, FACTS would not provide details of these recipients other than they were members of the FACTS 2001 scheme. There are some 5000 members of the FACTS scheme of whom approximately one third are registered in FACTS 2001.

In addition identifying independent agronomists representative of the target population was undertaken using the AICC and BIAC directories. Questionnaires were sent to all members who listed whole farm agronomy as their area of interest, but not to those members who specialise in what were judged to be less relevant areas such as crop protection, livestock management, financial advice, etc.

[48] An Independent Registration Scheme for the Pesticide Industry.

Table 4.1 Sources of information for drawing a sampling frame.

Organisations or individuals	Number of advisers in organisation	Source and selection of sample
ADAS	200 consultants 1200 total staff 16 regional offices	Questionnaires were sent to all regional ADAS offices for distribution to all relevant consultants and those involved in environmental protection. ADAS advisers were also covered through FACTS. 60 Questionnaires sent.
Organic Advisory Service	30	Questionnaires handed to all advisers working for OAS via EFRC. 30 Questionnaires handed out.
FWAG	63	Questionnaires sent to all FWAG officers. 63 Questionnaires sent
National Trust	10	Questionnaires sent to all Farm and Countryside officers. 10 Questionnaires sent.
ERDP Schemes DEFRA	119 APOs and POs in FRCA in 2001	Questionnaires sent to 8 ERDP regional offices for distribution to those considered most relevant. 36 Questionnaires sent.
Commercial Agronomy organisations	FACTS members: 1600	*FACTS emailed questionnaire to 700 registered in 2001. 700 Questionnaires emailed.
Independent Crop Consultants/ Agronomists	AICC 180 members BIAC 300 members	All AICC members (excluding crop protection specialists). Selected BIAC members providing relevant advice. Also covered through FACTS emailed questionnaire. 105 Questionnaires sent.

Although this non-probability sampling does not allow any statistical measure of representativeness to be calculated this collection of strategies ensured that as far as possible all advisers in the target population were included in the sample for all organisations apart from FACTS. Also a large sampling size reduced the risk of sampling error. Measures of representation for individual groups are not available but relevant advisers from all organisations were represented. The importance of samples lies in the accuracy which they represent or mirror the target population (Fink 1995); every attempt has been made here to achieve this accuracy.

4.2.2 Questionnaire design

It has been empirically supported that the length and format of a questionnaire, and the ordering and the style of questions can greatly influence the responses given by the interviewee and the risk of response error (Glastonbury and MacKean 1991). The design of this questionnaire intends to develop a coherent, and focused document, rather than a set of random questions, which is self contained and requires no further explanation. This questionnaire deploys different types of questions, the majority are closed pre-coded questions, although some of these are followed by the opportunity to provide examples. Closed questions are easier to code and subsequently analyse as well as allowing greater standardisation of the questionnaire format, however, they do tend to compartmentalise information into fixed replies and are unlikely to cover all possible answers (May 1997; Sarantakos 1998). A limited number of open questions were also included to allow some spontaneity and freedom of expression in the answers. This combination not only introduces some variety for the respondent, but also provides a richer picture for analysis. The question sequence leads from simple questions on adviser background through to questions relating to work experiences, as the themes on adviser links to researchers and farmers are developed.

Multiple response questions requiring categorical answers were used to measure frequency, ranking of importance and attitudinal measures. Attitudinal measures use a Likert-style scale in which statements are provided and respondents are asked to indicate the extent to which they agree or disagree. Care has been taken in scaling these responses using terms that have clear meaning to respondents, nevertheless there is always uncertainty over what these scales and the intervals between them actually represent to different people. Consideration has been given to making the instructions for the style of response precise with clear, exhaustive response categories proposed for the closed questions. Care was also taken to include definition of terms used in the questions such as 'soil degradation' and 'soil protection'. A copy of the questionnaire is provided in Appendix 3.

Because postal questionnaires are limited in their ability to reveal detailed information concerning actors' personal beliefs, attitudes and feelings (and because the qualitative phase offers the opportunity to explore these) it was decided that for the most part questions should probe actual practice and experience, since these were thought more indicative of the way advisers acquire, utilise, generate and transfer knowledge and of the mechanisms which might enable or constrain these processes within the AKIS. Most of the questions therefore required factual answers calling on the adviser's own background, experience and observations, only a few questions probed opinion or value.

The content is firmly rooted in the research objectives and there are three broad sections to the questionnaire which explore these. The first focuses on respondent variables, that is, the advisers' background, their organisation, their understanding of soil degradation issues and the practices they recommend. The second focuses on the advisers' interactions with the research community in terms of linkage mechanisms used and the communication of research results. The final section concentrates on the advisers' interactions with farmers, in terms of how knowledge is exchanged and advisers' observations of soil management practices on-farm. The latter sections intend to provide some insights into how the AKIS enable and or constrain knowledge processes.

4.2.3 Pilot study

A pilot study was carried out to ascertain how the questionnaire would function in practice in particular whether the questions were clear, the format comprehensible and the length appropriate. Possible misinterpretation of questions, question sequence, length and clarity and instructions were tested, while practical methods for delivery, return, length of time taken to complete were also scrutinised. Twelve advisers from a range of organisations were contacted and all returned their questionnaires fully completed. Some minor adjustments were made mostly to the format, but given the response rate and full completion of questionnaires it was concluded that the questionnaire was clear and comprehensible and of suitable length for a full scale survey to be effective. The results from the pilot were considered valid and are included within the main survey findings. Questionnaires were sent with an accompanying letter explaining the purpose of the survey (see Appendix 3).

4.2.4 Questionnaire responses

Response rates were acceptable for all organisations (ranging from 37-60%) where questionnaires were posted to recipients directly or through their regional offices.

The OAS response rate of 17% was disappointing, as one would assume being given a questionnaire at an OAS meeting by an EFRC researcher would provide some incentive to complete it. It was only possible to indicate response rates for ADAS and DEFRA based on the number of questionnaires sent to the regional managers, as it is not known if all of these were forwarded. For all these organisations 123 replies were received from a total of 304 giving an average response rate of 40%. According to Fink (1995) unsolicited surveys receive the lowest fraction of responses with levels as low as 20% not uncommon. These rates therefore compare favourably with the norm and provide a good basis for analysis and representation of the population is assured.

Table 4.2 Questionnaire response rates for organisations.

Organisation	**Number sent out**	**Number returned**	**Response rate %**
Posted			
Farm and Wildlife Advisers FWAG	63	25	40
Farm and Countryside Officers NT	10	6	60
OAS (handed)	30	5	17
AICC/BIAC	105	45	43
ADAS	64	22	
DEFRA	36	20	55
SUBTOTAL	304	123	40
Emailed by FACTS			
FACTS qualified (BASIS) includes some of the above	700	40	n/a
TOTAL		163	

Only 40 responses were received from the FACTS emailing. This very small response was attributed to the fact that the membership includes a large number of crop protection advisers and fertiliser trade representatives who would have regarded the questionnaire as irrelevant to them; that is, they were outside the target population. The method of calculating the response rate also tends to overestimate the non-response for mailed questionnaires because there is the assumption that a non-response is due to refusal rather than due to ineligibility. The questionnaire was also sent at a relatively busy time for agronomists during the autumn when crops are being planned and established. It is not possible therefore to determine a meaningful response rate. The 40 FACTS questionnaires were included in the analysis in the understanding that this group might be poorly represented. Poor representation of commercial agronomists can be addressed in the case study phase and by making reference to secondary research such as a survey carried out of commercial agronomists by Marshall (2002). Combining all the replies gives a total of 163 responses suitable for analysis.

4.2.5 Analysis of questionnaire data

With a large scale questionnaire survey the common focus is on representation which leads to numerical summary of results. The data derived from the questionnaire were categorical which refers to data whose value cannot be measured; descriptive or nominal data in which yes or no answers to closed questions reveal whether there are differences in patterns of responses; and ranked or ordinal data, where preferences from a set of questions are expressed.

The process of analysis started with coding the responses following the basic rules of coding set out by Fielding (1993: 225) that is, codes must be mutually exclusive, exhaustive and applied consistently throughout. The process involved development of a coding frame for the pre-coded and open questions, creating a code book, coding the responses, transferring the values to the PC and then checking and cleaning the data by looking for any errors of data entry and removing any extreme anomalies.

Analysis using the statistical package SPSS version 10 (Statistical Package for Social Scientists) was considered the most appropriate tool to summarise the data. Basic descriptive statistics were applied to describe proportions of the sample and frequency distributions both for the whole sample as well as for adviser categories. Five categories of respondent advisers were distinguished according to their organisations, these were: Conservation advisers (including FWAG and National Trust); DEFRA RDS advisers (including OAS); Independent agronomists[49]; Distributor agronomists (commercial); and ADAS advisers. The SPSS file was spilt accordingly for analysis and the number of cases in each category were computed and presented as proportions of the total as relative frequencies. The intention was to characterise advisers both as a whole and within categories in terms of the

[49] Also referred to as crop consultants or agricultural consultants.

knowledge processes they engage in and the linkage mechanisms they used, rather than determine any relationships between the variables measured. Throughout the analysis it should be acknowledged that the meanings attributed to responses to closed questions are the attributes applied by the researcher, while for open questions interpretation is more provisional and contentious (Arksey and Knight 1999).

4.3 The case studies

The philosophy of the actor-oriented perspective, with its emphasis on understanding the individual, suggests the use of qualitative methods which aim to understand people rather than measure them and to interpret human meaning and action in context (Punch 1998; Sarantakos 1998). The case study is believed to be essential to the actor-oriented approach and in particular the analysis of the social interface which emphasises that the understanding of knowledge processes must be situated in terms of the life worlds of the individuals and groups involved (Long 1989). Case studies provide a device for exploring these life worlds in depth and how relationships are experienced (Denscombe 1998). Many of the features of case studies are summed up by Yin (1989:23) who asserts that 'the case study is an empirical enquiry that investigates a contemporary phenomenon within its real life context; when the boundaries between phenomena and context are not clearly evident'. Case studies, however, are mainly associated with qualitative methods as Hamel et al. (1993: 39) state 'the case study approach has proven to be in complete harmony with the three key words that characterise qualitative method: describing, understanding and explaining'.

Case studies involve studying a phenomenon within a real life setting, where a spatially and temporally specific example is chosen for study. This allows a particular issue to be studied in depth and from a variety of perspectives, by including different accounts and interpretations, in doing this it relies on multiple sources of evidence (Kitchen and Tate 2000). Case study analysis allows a dynamic interpretation of actors' relationships and interactions to be constructed and placed in a specific social, and institutional context. Although previously considered an inferior method of inquiry limited by lack of quantification or possible generalisation, today case studies are accepted as a valid form of inquiry in the context of descriptive as well evaluative and causal studies. This is particularly the case when the research context is too complex for surveys or experimental strategies and where the researcher is interested in structure, process and outcomes of a single unit (Sarantakos 1998). Combining case studies with a large scale questionnaire allows them to be embedded in a much wider context but at the same time provides detailed illustrative cases which enhance the survey data.

4.3.1 Selection of case studies

The selection of case studies involved three stages: first a general review of all soil management related initiatives within England was undertaken by consulting recent reports (ECOTEC 2000; Archer 2001; Dampney et al. 2001) and assisted by the questionnaire data; secondly identification and selection of particular case studies and thirdly selection of interviewees and events to attend within the case studies.

The diversity of research projects and knowledge transfer (KT) initiatives which encompass soil management in England has already been discussed in Chapter 2. The Register of Agri-Environmental R and D (MAFF 2001a) lists over 100 research projects concerned with soils and agricultural practice for 1999/2000, while recent reviews by Archer (2001) listed 45 KT projects and Dampney (et al. 2001) identified 'hundreds of initiatives' in the AgriComms survey of environmental protection and conservation advice. Given the number of possible case studies it was necessary to closely consider the aims of the research in selecting case studies, which are to investigate the role that agricultural advisers play in the acquisition, utilisation, generation and transfer of knowledge about soil best management practice and to elicit the factors that enable and constrain these knowledge processes. Clearly then the case studies need to:

- have within them some element or intention to achieve sustainable soil management through exchange or dissemination of knowledge about soil best management practice;
- involve advisers as well as actors from the research and farming communities with whom they interact;

- address a range of soil related problems and provide a range of best management practices which make demands on advisers' skills and knowledge; and
- be practical and achievable given the constraints on time and money.

Both research and KT initiatives in England tend to emphasise environmental protection rather than soil management *per se* as revealed in Chapter 2. Many of the research projects are very specialised nutrient dynamic studies, for example, investigations of the nitrogen cycle in agricultural soils. Meanwhile, most of the KT activities are short-lived dissemination efforts using one-off publications and seminars and lack any long-term development. Three cases, however, did emerge which met the above requirements and which were sufficiently different to allow a range of issues and situations to be explored:

- *The UK Soil Management Initiative (SMI)*

  An independent organisation created to promote the adoption by UK farmers and advisers of systems designed to protect and enhance soil quality. The project addresses mainly soil structural degradation through cultivation practices and is based on research from the IFS LIFE project.

- *The Landcare Project*

  An Environment Agency pilot project established to improve awareness of diffuse pollution in the Upper Hampshire Avon catchment amongst the farming community. It aims to reduce soil wash and nutrient leaching by promoting a range of best management practice amongst farmers.

- *SUNDIAL Fertiliser Recommendation System (SUNDIAL-FRS)*

  A predictive tool for farmers developed by Rothamsted, with MAFF funding, from a research tool in consultation with advisers and farmers. It aims to improve farmer nitrogen (N) fertilisation efficiency and reduce leaching.

Further details of these case studies are presented in sections 4.4 to 4.6.

Table 4.3 Characteristics of the three case studies selected.

	CASE STUDIES		
	SMI	**Landcare**	**SUNDIAL-FRS**
Aims and issues	Aims to prevent soil structural degradation	Aims to reduce diffuse pollution from soil wash and nutrients	A PC based tool that aims to reduce nitrate leaching and optimise N fertiliser use and yield
Best management practice	To improve soil structure through appropriate cultivation and other practices integral to IFS	Nutrient budgeting; sensitive cultivation and establishment to reduce soil wash	Adjust rates of N fertiliser to synchronise with crop needs thereby reducing leaching
Length of project	1999-present	1996-present	1996-99
Originators	Researchers associated through the LIFE IFS project	Environment Agency based on concerns and a mixture of evidence	Rothamsted researchers using the SUNDIAL research model
Organisation	NGO with diverse membership	Partnership of Environment Agency with other stakeholders	Rothamsted under a MAFF funded contract
Adviser involvement	Inside project: Project members	Inside project: Project members	Inside project: Used to access farmers and evaluate FRS
Target groups	All arable farmers and advisers	Farmers and advisers working within Landcare catchment, particularly mixed farms where maize is grown or outdoor pigs	Arable farmers and advisers seeking to optimise efficiency

There are criticisms to the case study approach which focus on case study selection, with representiveness and generalisability viewed as the major methodological weaknesses. Bias and subjectivity are inherent features of the approach which to a large degree are dependent on the preferences and decisions of the researcher, who ultimately decides on which case studies to choose, which actors to interview and how much time to allocate to individual interviewees (Hamel et al. 1993). In this respect concern has been expressed about the failure of case studies to represent the wider sample under investigation. It is not the intention with these case studies however, to be representative, rather they are illustrative providing a view within the broad spectrum of the initiatives that exist within England. The three case studies demonstrate breadth in terms of: project aims, project strategies, approaches to knowledge transfer, participant actors, aspects of soil management, funders and in the degree of personal interaction between farmers and researchers and advisers (Table 4.3).

Another common misconception is that multiple cases are used for the purpose of gathering a sample of cases so that generalisation to some population can be made (Robson 1993). These case studies have not been selected as 'typical' and although some generalisation may be possible this was not the intention in this study.

4.3.2 The boundaries of the case studies

One consideration in case study design and analysis is the nature and extent of the case study boundary. Relationships and interactions of individuals can be extensive and often go beyond the limits of the specific study (Robson 1993; Murdoch 1994). Access to actors, researcher preferences and other practical considerations such as available time will inevitably dictate the extent of the study. In the context of this research the boundaries of the case studies selected are to some extent delineated by the boundaries of the projects chosen, although networks of the associated actors do transcend these.

4.3.3 Methods of data collection

The conceptual framework, the research questions and the sampling criteria largely determine the approach to data collection in case studies (Robson 1993). In this research, which demanded understanding of individual actor's activities, strategies, and life worlds, face to face interviews were considered the most appropriate methods, as May (1997: 109) states 'interviews yield rich insights into people's experiences, opinions, aspirations, attitudes and feelings'. Interviews also uncover meanings that underpin people's lives, routines, behaviour and feelings, all of which influence advisers' engagement in knowledge processes (Arksey and Knight 1999).

Semi-structured interviews were chosen, rather than structured or open interviews, to allow for some degree of conformity and standardisation which facilitates comparability between interviews. They also permit sufficient flexibility, and enable clarification, elaboration and discussion to reach greater depths of understanding.

With this in mind interview schedules were devised to ensure some consistency in the interview themes and procedure and to facilitate analysis. Details of the interview schedules for each case study are presented in Appendix 3.

Although the strength of interview is that it allows flexibility and the discovery of meaning, some weaknesses of this method need to be acknowledged. Interviews tell the researcher little about the reality that is external to the interview and cannot produce data which reflects a real world beyond interpretation. They assume a link can be made between a person's account of an action and the action itself, however, accounts given in interviews might be inaccurate and give no indication of the circumstances surrounding these accounts. How the interviewee and the interviewer mediate the process is also significant. The interviewer's role is important in terms of how they balance the need to establish a rapport and ask objective questions. Lack of skills of interviewers in directing the interview and in using the appropriate language can lead to misunderstandings, bias or false responses (May 1997).

For this reason other methods were employed to supplement and triangulate the interview data. These include a literature and web site review, analysis of documentation and observation of events and meetings. Observing advisory farm visits was not possible because of FMD but some events attended allowed some insights into adviser interactions with researchers and farmers first hand.

4.3.4 Interview themes and questions

Interviews addressed themes pertinent to the research objectives but within the context of each case study (see individual case studies). Questions relevant to individual case studies were prepared and the same principle questions were asked each time although these were adjusted according to whether the interviewee was an adviser, researcher or farmer. The sequence of questioning was also flexible. Questions common to all interviews aimed to explore:

- the advisers' role in acquisition, utilisation, generation and transfer of soil best management practice knowledge in relation to the aims of the project used as the case study;

- the factors that enabled and constrained advisers in supporting soil best management practice promoted by the respective project used as the case study; and
- the differential responses of the actors to the soil best management practice in question and how the resulting 'interpretative struggles' affected the exchange of knowledge.

Opportunities were also taken to ask interviewees about their views on a range of relevant themes beyond the individual case study. Interview questions therefore were not confined by the boundaries of one particular case study. Interviews were carried out at a venue and time suited to the interviewee and were recorded and later transcribed. Recording the conversation allowed the interviewer to concentrate on the process and made the occasion more relaxed.

4.3.5 Sampling for interview

In selecting candidates for interview reference was made to the principal aims of the research. The case studies offer a range of adviser interactions which can be studied and to take full opportunity of these it was considered that interviewees should include:

- representatives of advisers, researchers and farmers active within or directly associated with the project, to give an 'insider's' view; and
- representatives of advisers, researchers and farmers not directly active within the project but interacting with it (e.g. because they are targeted recipients of project information, work in the same geographical region or attend the project events), to give an 'outsider's' view.

The importance of including all members of the project or case under study is emphasised by Riley (1963), not only to avoid obtaining a limited perspective, but also to ensure the integrity of the case in question and therefore its unitary character. Accordingly all the key project members, including researchers, advisers and farmers, central to and active within the project were interviewed, with availability and unwillingness to be interviewed the only constraints to inclusion.

Advisers, farmers and researchers not associated with the project but nevertheless subject to its influences are a more diffuse, peripheral and less easily delineated group. They were also more numerous and selection of a sample for interview was necessary. In developing a sampling strategy, it was important to include a representative range of advisers from the different organisations and communities in which they operate (Robson 1993). Advisers were selected from those who attended project events, were recommended through the snowball technique or were working in the geographical area of the project. Researchers from outside the project were selected for sharing the same disciplinary interest as project members while farmers were selected through attendance at project events, or location within the project area.

4.3.6 Analysis of case studies

The intention of the analysis is to interpret and explain the different interviews in the context of the study through exploring patterns in the lives and words of the people. Detailed analysis of the interviews involved first assigning meanings to data and devising concepts that will be analysed, refined and put into categories. In identifying categories and assigning codes the aim should be that the categories are 'grounded', that is rooted empirically in the data and conceptually in the research issues (Arksey and Knight 1999). The use of semi-structured interviews assists this process as the themes for the interview reflect the conceptual basis of the study. Thus coding was done on the basis of concepts, identified by looking for underlying themes relevant to the study.

One of the fundamental problems in case study research is fitting together the data from all the actors involved (Riley 1963). Full transcripts were prepared for all interviews, which as Arksey and Knight (1999) note is essential to identify emergent themes, issues and personal stories. This proved important in familiarisation with the data and enabling initial identification of recurrent themes. The highlighting function of Word was used to denote different passages in the interview transcript that demonstrated particular themes or statements relevant to the research objectives. At the same time a coding table describing the categories was developed and constantly modified and added to, as each transcript was analysed, in an iterative process. A 'cut and paste' approach was used to assemble examples of statements indicative of certain concepts.

Throughout the analysis it must be acknowledged that the data has been collected within a certain interactive context and must be analysed with that in mind taking care not to use comments outside their context. Inevitably, researcher presuppositions influence the interpretation of data and this also needs to be considered (May 1997).

4.3.7 Presentation of results

In recognition of the possible methodological weaknesses of the case study approach, this research employs a multi-method strategy where quantitative methods, which allow representation and generalisation, are also used and as such, support, complement and contextualise the case study analysis. The presentation of results aims to reflect this complementarity by combining questionnaire and the case study results and presenting them according to shared themes. Although some themes are more heavily illustrated by certain case studies than others this was felt to present the 'bigger picture' and be more appropriate to the research objectives.

4.4 The UK Soil Management Initiative (SMI)

4.4.1 Introduction

The UK Soil Management Initiative (SMI) is an independent organisation created to promote the adoption by UK farmers and advisers of systems designed to protect and enhance soil quality. It intends to achieve this through information transfer and advice.

4.4.2 Background

SMI is based on the understanding that, through improved soil management notably sustainable cultivation systems, agronomic, economic and environmental benefits may be accrued. Evidence used to support this comes from research conducted as part of the Less-Intensive Farming and the Environment project (LIFE) at IACR-Long Ashton where integrated systems, involving reduced tillage, were compared with conventional systems where the plough was used (Jordan et al. 1997; Jordan et al. 2000; Jordan 2001). The results showed that compared with ploughing, reduced tillage substantially decreased sediment loss in run off, total and soluble phosphorus (P) losses, and isoproturon loss in drainage; resulted in larger numbers of earthworms than the conventional system, had comparable yields to ploughed plots while the cost of crop establishment was reduced by one third. Other research projects supported these results: the Focus on Farming Practice project at CWS-Stoughton (Leake 2001); and Integrated Farming Systems/LINK project led by ADAS. Members of these research projects were linked by their shared interests and enthusiasm for IFS. This association was formalised when, in response to funding opportunities from European Conservation Agriculture Federation (ECAF), SMI was formed with the aim of disseminating the research results to the practical community.

4.4.3 SMI objectives

SMI was set up as a non-profit making limited company in January 1999. SMI is part of ECAF which is made up of individuals from the 11 national associations working across Europe to implement sustainable soil management. It is funded by the EU LIFE fund as well as member organisations. DEFRA has given funds for a key publication (Soil Management Initiative 2002). SMI objectives are:

- To improve technology transfer through extension to farms.
- To promote agricultural and environmental policies supportive of sustainable soils management.
- To improve information exchange in the research, policy and practitioner communities.
- To research, develop, evaluate and promote soil management systems to improve crop production and protection of the environment.

Box 4.1	SMI Members 2003
ADAS:	Dr Andrée Carter (Vice Chairman); Paddy Johnson (board member)
AAE Bioservices	Dr Vic Jordan (board member CEO)
Allerton Trust	Alastair Leake (board member Chairman)
Environment Agency	Richard Smith, Rob Robinson
Farmcare	David Gardener and Peter Thompson
Farmeco	David Rose and Keith Challen
Game Conservancy Trust	Dr John Holland (board member)
John Deere	Chris Meacock
Lo-Till Club	Jim Bullock (Farmer, board member)
Landview Associates	Michael Harrington
Masstock Arable UK Ltd	Andrew Richards, Jim Ferguson
Monsanto UK Limited	Clive Sutton
National Soil Resources Institute	Ian Bradley, Dr Tim Harrod
SAC (Scottish Agricultural College)	Bruce Ball
Simba International Ltd	Rod Daffern
Stride Forward	Colin Stride (Company Secretary)
Syngenta	Iain Hamilton
Steve Townsend and Company	Steve Townsend
The Farmers Conservation Group	David Bird
Unilever	Jos-Van Oostrum
'Vaderstad	Tim Needam

SMI membership is composed of representatives from larger organisations (Box 4.1) who pay a membership fee in proportion to their turnover (details in Appendix 3). The board is composed of 5-6 founding members who have full time employment in other organisations and give their time freely to SMI activities. The strength of SMI is seen as its bringing together of a wide range of commercial and research interests and the experience of its members, which provides a basis for the exchange of information within the industry (Davies and Finney 2002).

Farmers as individuals are not included in the membership because the organisation has insufficient staff and funds to administer a large individual membership. Also, with the length of funding so uncertain, it was felt that long-term benefits to farmers were unclear. Instead, farmers are invited to all SMI events and a parallel organisation called the Lo-Till club caters for exchange between farmers. SMI is active at a number of arable events while specific dissemination activities include breakfast roadshows and day workshops for farmers, advisers and others in the industry, an online question and answer service (on Farmers Weekly Interactive) and

Box 4.2 Extract from SMI website (SMI 2004)

Sustainable soil management is critical to maximise cost-efficient arable production

Examination and investigation to find the causes of the problems followed by implementation of appropriate improved management practice can reduce the environmental damage and improve the economic returns. Such practices include revised plough tillage, well managed conservation tillage, removal of sub-/ surface compaction and better livestock stock management (grazing, feeding , tracks). Current practice means many fields are suffering soil degradation. This is seen as increased difficulty in working soils as they lose aggregate structure, become cloddier, with increased compaction and reduced water infiltration. All of these impact on crop production and yields, reducing profit potential.

Sustainable soil management is vital to protect our environment from pollution.

Currently 2.3m tonnes of soil is eroded annually (Soil Survey '99) much of this ending up in our rivers. This soil, along with pesticides and nutrients cause pollution and are ruining fisheries. Adopting appropriate soil management practices can reduce these effects and also encourage wildlife in our crops. Air quality benefits through lower energy consumption and the locking up of carbon dioxide as carbon in the soil.

many publications. Through emphasising cost saving and working through the commercial community SMI have attracted a large number of farmers to meetings and their publications have been very popular (see Appendix 3).

4.4.4 Issues addressed by SMI

SMI addresses the problem of structural degradation of soils caused through over or poorly timed cultivation activities, as their web site explains (see Box 4.2). To address these concerns SMI propose a number of best management practices, which emphasise good cultivation practice. These point to unnecessary over-working of soil, which is both expensive, and degrading, and also emphasise inspection of the soil (see Appendix 3). The management principles are based on an understanding of soil structure.

The emphasis on reduced tillage is in response to strong commercial interests, membership of ECAF and farmers' enthusiasm. With the pressure on cereal growers to reduce crop establishment costs, reduced tillage offers opportunities to achieve this because they are less expensive than traditional systems; being less energy demanding, and/or quicker and/or have a lower labour demand (Davies and Finny 2002). The cost saving benefits of these practices are promoted widely by the project (see Appendix 3 for examples of promotional material).

4.4.5 Reduced tillage in the wider context

In the UK a range of terms are used to describe reduced tillage including Minimum Tillage, Lo-Till, Conservation Tillage, ECOTillage[50], they all refer to shallower, non-inversion cultivation that is plough-free.

Management demands

Whilst it is generally agreed that reduced tillage systems have the potential to cut overall farm costs, to be sustainable they do, however, require a higher standard of overall management than ploughing. A recent HGCA review states 'Conventional farming based on the plough owes its great popularity to its almost universal applicability and reliability. Reduced tillage on the other hand needs to be tailored carefully to site, soil condition and weeds to be successful.... The requirement for close field and in-field management means that the risk of compromising yield is greater and that good judgement and strong motivation to make the system work are necessary ingredients of success. Furthermore the shallower the depth of work, the more the risk involved and the skill required.... Adoption of reduced tillage purely because it is widely and persuasively promoted is a recipe for failure.... It is only severe financial pressure which is forcing large numbers of farmers to adopt quicker cheaper tillage for their combinable crops, and this fact alone emphasises that reduced tillage is not an easy option.' (Davies and Finney 2002:38). The review suggested that widespread uptake of reduced tillage may cause as many problems as it solves. Potential disadvantages mentioned were poorer establishment, slugs, worse grass weed problems and more topsoil compaction resulting in more run off

[50] To most practitioners 'minimum or minimal tillage' probably signifies 'shallow tillage' (<100 mm without inversion), but in practice often includes 'direct drilling' (no cultivation prior to drilling) and deep tillage (>100 mm without inversion). 'Lo-till' and 'ECOTillage' are defined more specifically as equivalent to 'shallow tillage'. 'Conservation tillage' is a widely used international term describing any non inversion tillage which leaves at least a third of the soil surface covered by crop residues; it includes direct drilling, shallow and deep tillage, provided they pass the residue test. 'No-till' and 'Zero-tillage' are equivalent to 'direct drilling' (Davies and Finney 2002).

containing pollutants. The success and failures are attributed to management and attention to detail. Having the ability and experience to weigh up the various factors, which determine optimum depth of work, are thought to be crucial.

Reduced tillage is not universally applicable either; suitability of farms for reduced tillage varies widely depending mainly on annual rainfall, soil type and cropping system. The stable structured well-drained soils in lower rainfall areas have the best opportunity for saving tillage costs and weakly structured or slow draining soils in wetter areas have less opportunity. Grass weeds competition is a major constraint on reduced tillage and on shallow reduced tillage in particular. The magnitude of the problem on farms with large populations of herbicide resistant Black Grass or Ryegrass is such that the need for deeper tillage and occasional ploughing inevitably restrict the opportunity for saving tillage costs.

Contested environmental benefits

There is also a difference of opinion about the environmental benefits of reduced tillage. Whilst these are emphasised by IFS researchers and SMI, others have pointed out that under commercial practice these might not occur. The HGCA review concluded 'The environmental benefits of reduced tillage on farms, as distinct from experiments, are unclear, sometimes contrary and far from assured' (Davies and Finney 2002: 5). Caution has also been expressed about claims of the beneficial effects of reduced tillage to soil. Results from experimental plots with reduced tillage have shown that run off and losses of soil were substantially reduced compared with ploughed, this was attributed to better surface structure and residues (Chambers et al. 2000; Jordan et al. 2000). However, it has been pointed out that to expect the general application of shallow tillage to control surface run off in vulnerable catchments overlooks the fact that reduced tillage always has to be tailored to site and soil condition and the consequences of it being wrongly applied can be severe. The Environment Agency who previously recognised conservation tillage as a 'best farming practice' for controlling run off and soil loss from fields (Environment Agency 2001) now express concern that in some recent case studies run off was not controlled by shallow tillage and they now have misgivings about its general efficacy (Davies and Finney 2002).

Advice for farmers and consultants

Changing from one system of tillage to another involves a major shift in how a farm operates and needs support, particularly as the requirements of each farm will be different, depending on the soils, pests, rainfall and individual financial, labour and technical circumstances. With such a management demanding system farmers would benefit from comprehensive independent advice from experienced consultants. The HGCA review suggested that the availability of such advice is quite limited amongst those consultants who are regularly on farms.

Clearly the SMI case study needs to be considered in the context of the above, that reduced tillage is more management intensive, more risky, not universally appropriate, lacks advisory support and the claimed benefits to the environment and the soil are contested.

4.4.6 Relevance to this research

This project is unique in the UK as it focuses on sustainable soil management for profitable crops and as such emphasises the soil's productive function. Active board members have a strong research background but also provide an advisory role. They maintain strong links with research, trade and farming communities. Responding to farmers' commercial interests is central to the thrust of the project. There is opportunity in this context to study a range of advisers with close research links as they negotiate different roles both within and outside the project. In addition the practical community, farmers and advisers alike, who interact with project members and represent the target audience, are equally important. Given the intensive and new management demands of reduced tillage and the need for support from advisers, this case study also provides an opportunity to explore whether the advisory community possess the required experience, skills and competence.

4.4.7 Methods and selection for interview

Interviews were conducted with a range of actors from all communities both within and outside the project as listed respectively in Table 4.4 and 4.5. Interviews with farmers who had attended SMI events are listed in Table 4.6 and project events observed as part of this research are listed in Table 4.7.

Table 4.4 Interviews with SMI board members.

RESEARCHER/ADVISER	Organisation	Position
Researcher/adviser	ADAS	Vice Chairman
Researcher/adviser	ADAS	
Researcher	AAE Bioservices	CEO
Researcher/adviser	Allerton Trust	Chairman
Researcher/adviser	Environment Agency	
Researcher	Game Conservancy Trust	
Agronomist	Monsanto UK Limited	Company Secretary
FARMERS		
Mr S	Established Lo-Till club	Demonstrates
Mr F	Direct drill farmer	

Table 4.5 Interviews with researchers and advisers outside SMI.

RESEARCHERS	Relevant experience
ARC representative	Conducts relevant research
British Sugar representative	Conducts relevant research
ADVISERS	
Independent agronomist	
Independent agronomist	
Independent agronomist	
Commercial agronomist	
Commercial agronomist	
ADAS adviser	
Consultant	Research and advisory experience

Table 4.6 Interviews with arable farmers who attended SMI demonstration days

Farmer C	Market Harborough
Farmer M	Hatfield, Herts
Farmer P	Slatburn, Cleveland
Farmer RR	Oakham, Rutland
Farmer P	Rearsby, Leicester
Farmer J	Market Harborough
Farmer H	Canterbury. Kent
Farmer PP	Melton Mowbray

Table 4.7 SMI events observed as part of this research.

SMI Demonstration day	Allerton Trust, December 2001
Vaderstad Lo-Till event	Stoneleigh, September 2002

4.5 The Landcare Project

4.5.1 Introduction

The Landcare project is being piloted by the South West Region of the Environment Agency in the upper Hampshire Avon catchment. It aims to work in a partnership approach with the farming community and others to raise awareness of the diffuse farm pollution problem and to obtain wide-scale implementation of Better Farming Practices (BFP) to control it.

4.5.2 Background

Diffuse losses of soil and accompanying nutrients (nitrogen and phosphorus) and pesticides from agriculture to rivers causes deterioration by silting up of spawning grounds in trout and salmon rivers (MAFF 2000c), eutrophication in lakes, reservoirs and slow moving rivers due to phosphorus enrichment (Environment Agency 2000; 2004b), and occasional flooding of roads and houses. Although there is increasing evidence of the problem the Agency has limited statutory powers to control water pollution from farmland surface run off, unlike point source pollution from agriculture where a combination of regulation and advice have proved effective in reducing levels (Dwyer et al. 2002).

The Upper Avon catchment is important for nature conservation and fisheries comprising a number of sensitive chalk streams. Towards the late 1990s the Agency began to suspect that soil erosion problems were affecting water quality and fisheries of the rivers and that agricultural practices on the farms in the catchment were largely to blame. There are approximately 350 farmers living in the Landcare area mostly engaged in mixed farming. Following research undertaken by Environment Agency staff in US and Australia, where community-based initiatives have been effective to combat diffuse pollution and soil erosion in rural areas, Landcare was established as a pilot catchment based scheme in 1996 covering roughly 950 km^2 of the 17,000 km^2 catchment.

In the early stages of the project the focus was specifically on the issue of soil erosion and the promotion of Best Farming Practices (Environment Agency 2001) which would help prevent this. Farmers were encouraged to join the Landcare Group and a Project Officer (from the Environment Agency) was assigned. A combination of literature (including a toolkit) and demonstration were used to raise awareness of the problem and best management practice. The key throughout was communication to farmers of the diffuse pollution problem and the role of agriculture in causing it. However, lack of engagement of farmers, attributed to their poor relations with the Environment Agency, and lack of funding and commitment from agencies outside the project led to a shift in emphasis from late 1998 onwards. Rather than focusing on farmers the project sought to draw in representatives from a wider range of interested 'stakeholder' groups into a Landcare Partnership (Box 4.3). By involving representatives from farming organisations, agricultural advisers, water companies, conservation groups, landowners, statutory bodies and local authorities wider interests in the catchment were served and the possibility of integrating environmental advice from the different agencies improved. Also by using a partnership approach, the Environment Agency was perceived to have a less dominant role than before.

There has been criticism within the partnerships about the lack of farmer representation, some arguing that the partner members are those 'with the problems' rather than those responsible for them and their solution. A key move in this phase, however, was the establishment of workshops with the aim of getting farmers and advisers to take 'ownership' of decisions on the trial farm. Using independent advisers to make presentations to farmers has been recognised as a useful strategy throughout. Some partners are very active, for example, the consultant who represents BIAC and representatives for English Nature and the NFU, while others are nominal, only turning up for biannual meetings. Some partners, notably the RSPB, have not continued their interest.

Box 4.3 The Landcare Partnership in 2000

Bournemouth and West Hants Water Co
British Independent Agricultural Consultants represented by consultant from Fieldfare
British Institute of Agricultural Consultants (BIAC)
Country Landowners Association
DEFRA (joined in 2002)
DEFRA's ERDP represented by Project Officer for Test and Avon ESA
English Nature
Environment Agency
Farmer representative for Pembroke estates
Farmer representative from Dorset
Game Conservancy Trust
MOD (Defence Estates Organisation)
National Farmers Union
RSPB
Salisbury District Council
Wessex Salmon and Rivers Trust
Wessex Water
Wiltshire County Council
Wiltshire Fisheries Association

Throughout, the project has suffered from a lack of money and staff support within the Agency. At the time of the study the EPO in the catchment had 0.5 of his time allocated to the project, with the other 0.5 spent on Environment Agency duties such as regulation. A major benefit from involving more stakeholders was not only to widen the scope of the project but also to enable new funders to be involved for e.g. English Nature and DEFRA. Complementary initiatives within the catchment include the Wessex Outdoor Pig Partnership (DEFRA funded). The Maize Growers Association (MGA) has also been involved through its representative independent agronomist and in undertaking research on soil erosion under maize in collaboration with the Environment Agency.

Recent events, which have impacted the project, include the introduction of NVZs, which has focused farmers' minds and made them more active in seeking out information from the Environment Agency. Bids for more funding to support integrated advice within the project have meant that a full time Project Officer has been employed since the study took place. Project Officers have also been employed for other Landcare projects in the Test and Itchen Valley and the Rother Valley, suggesting that the Environment Agency has found a successful model it wants to reproduce[51].

4.5.3 Previous farmer surveys

Two surveys of farmers' attitudes have been undertaken in the catchment. A baseline survey of farmers' attitudes to environmental issues in the area and the use of best management practices was carried out by University of Nottingham in 1997 (Seymour et al. 1998b). Accent Marketing and Research were commissioned to undertake a follow up farmer survey in 2001 (Accent Marketing and Research 2002). Both farmer surveys revealed that although some farmers were aware of soil erosion issues they felt that pollution from highways, industries and sewage was neglected and that water abstraction was of greater concern. They were generally aware of regulations and avoided making mistakes and some felt they were already practicing best management practice, although were not all convinced of their financial benefits. They had mixed views about the Environment Agency and few remembered receiving the toolkit, which was sent to all farmers. There were few changes in awareness and attitude between the two surveys (1997 to 2002) and this was attributed to the same economic constraints prevailing in farming.

4.5.4 Best management practices being promoted by Landcare

The main practices identified as leading to diffuse pollution in the catchment are:

- untimely cultivation;
- maize - late cultivation and excessive manure application;
- outdoor pigs;
- inappropriate manure applications; and
- lack of nutrient budgeting.

[51] DEFRA (2004e) have proposed the use of a network of catchment officers in their consultation of measures to combat diffuse pollution based on the Landcare model.

Box 4.4 Best management practices for soil promoted by Landcare

- *Protecting soil structure*
  Examine soil properties regularly, avoid compaction, capping, overworking through timeliness of cultivation, avoid cultivation when too moist or wet, use rougher seedbed finishes and rough finishes after late harvested crops to avoid run off; maintain soil organic matter.

- *Establishing crops*
  Timeliness and careful examination of water and soil conditions. Consider reduced tillage and plough options very carefully.

- *Protecting soil from run off*
  Cultivate across slopes, use cover crops, grass, hedges and trees to reduce run off.

- *Protecting soil from compaction and damage by livestock*
  Avoid overgrazing and poaching, take care in location of farm tracks and feeding areas.

- *Managing manures*
  Realise the value of manures, use a nutrient management plan to allow for manure nutrient content, avoid run off of manures and unnecessary build up in the soil, at the same time improve soil fertility and structure and reduce need for artificial fertiliser.

- *Targeting artificial fertilisers*
  Apply fertilisers according to requirements – target amount and timing to crop needs, test soil and manure nutrient content to account for these, calibrate spreader.

A range of best management practice is being promoted in the catchment in response to these practices. These are described in detail in the following publications: Environment Agency (2001), Chambers et al. (2000), Dampney et al. (2001) and ADAS (2000a), and summarised in Box 4.4. Those relating to nutrient management, in part, represent the outcomes from the nitrate research programme described in Chapter 2 (MAFF 1999c; Powlson 2000).

4.5.5 Relevance to this research

This project addresses general soil management problems, which lead to run off and poor water quality. Advisers involved in the partnership come from diverse groups: independent consultants from BIAC and the MGA; Environment Agency EPOs; ESA Project Officers; and GCT and NFU representatives. Advisers not associated with the project but working within the catchment are equally important and include a number of agronomists and representatives from FWAG. This project provides the opportunity to study advisers' interfaces with each other and with the farming and project communities. The project provides opportunities for exploring advisers' use of best management practice which are more demanding on skills and competence, such as nutrient budgeting and managing manures.

4.5.6 Methods and selection for interview

A combination of interviews with actors from inside and outside the project and attendance at Landcare events informed this research. Interviewees within the Landcare partnership were selected from the partnership list with the aim of including all members (advisers, researchers and farmer representatives) who had an interest in farming activities (Table 4.8).

Table 4.8 Interviews with partners in the Landcare project.

RESEARCHERS/ADVISERS	PARTNER REPRESENTED
Researcher (J)	Game Conservancy Trust
Researcher/adviser (A)	Environment Agency
Local EPO/Project officer (W)	Environment Agency
Researcher/adviser (B).	Environment Agency
ESA Project Officer	Avon and Test Valley ESA
NFU Group Secretary	South Wilts Branch NFU
Consultant with Fieldfare Associates(TL)	BIAC representative
Adviser (DJ).	English Nature
Representative (DT)	Wessex Pig Producers
Independent agronomist (SD)	Contracted to MGA and EA
FARMER REPRESENTATIVES	
Mr G: Manager of farm where first demonstration plot was located	Representative for the Pembroke estate
Mr D: Current demo/workshop farmer	

Interviews outside the Landcare partnership included local advisers and farmers (Table 4.9). These were chosen from listings of agronomists active in the catchment. Farmers were selected from those farming within the Landcare area. A recent farmer survey (Accent Marketing and Research 2002) had led to 'research fatigue' amongst farmers and many refused to be interviewed. Outdoor pig farmers were not included as members of the Wessex Pig Producers group had recent experiences of farmers finding such interviews too confrontational. However, observation at the focus groups and results from a recent survey carried out by Accent Marketing and Research, which involved a range of farmers throughout the catchment, compensated for the small number of farmer interviews. A list of events observed is presented in Table 4.10.

Table 4.9 Interviews with advisers and farmers outside the Landcare project.

ADVISERS	
Commercial Agronomist	Pearce Seeds, Sherborne (RB)
FWAG Adviser Wilts	FWAG
Regional Director	Velcourt Farm Management Company
Distributor Agronomist (TB)	Cleanacres, Masstock
Distributor agronomist (GB)	UAP
Independent Agronomist (JC)	
Agronomy trials officer (DL)	Cleanacres, Masstock
Researcher/advisers	ADAS
FARMERS	
Mr R	Cereal farmer on Chalkland (Chair of Chalklands Cereal Group)
Mr BB	Cereal farmer Chalkland
Mr B	Mixed farmer Chalkland
Mr MF	Mixed farmer Pewsey vale clay

Table 4.10 Landcare project events observed as part of this research.

EVENT	Venue and date
Workshop Day for farmers and advisers	East Knoyle Farm, December 2001
Landcare partners meeting	April 2002
Farmer survey presentation by Accent Marketing and Research	April 2002
Two Farmer Focus Groups led by Accent Marketing and Research contracted by Environment Agency each with approximately 20 farmers (see Appendix 3).	Pembroke, Salisbury, January 2002
Environment Agency presentation and field trip day for Agency advisers	Meriden, Warwickshire, September 2001

4.6 SUNDIAL Fertiliser Recommendation System (SUNDIAL-FRS)

4.6.1 Introduction

SUNDIAL-FRS is a Fertiliser Recommendation System being developed as a PC operated management tool to help farmers, growers and advisers predict inorganic nitrogen (N) fertiliser requirements which will enable both desired yields to be achieved economically and nitrate leaching to be minimised. The project, which ran between 1996-1999, was funded by MAFF and researchers at Rothamsted undertook the work to develop the tool.

4.6.2 Background

Improving the efficiency of nitrogen use by crops is thought important both to maximise farm profitability and to minimise the adverse effects of nitrate leaching and pollution of watercourses. In recent years MAFF has sponsored a large programme of research on nitrate losses from agriculture, of which £1.8 million was spent on devising improved recommendations for nitrogen fertiliser use on arable and horticultural crops (MAFF 1999c). Fertiliser is needed to meet the shortfall between the crop's requirement for nitrogen (N) and the supply of N from the soil and organic manures. However, to ensure best practice on the whole farm, the need for fertiliser N must be individually assessed for each field and in each season. A significant barrier to more efficient use of N fertiliser by arable farmers is lack of information on seasonal, soil related and cultural variants in the supply of mineral N by soils and the requirements for nutrients by the crop.

Recommendation systems have been developed to predict the amount of fertiliser N which is economically optimum for the crop. Systems may be static or dynamic. Static systems are based on generalised or average information for the crop, soil and climate; they use simple, easily available information and are quick and easy to use. Static systems include RB209; FERTIPLAN (ADAS), NCYCLE (IGER) and systems developed by the fertiliser supply industry. Dynamic systems take account of more factors by following N changes in the soil/crop system as they occur and are more complex. Dynamic systems include WELL_N (HRI) and SUNDIAL-FRS.

A FRS works by using calculated crop N off-take and nitrate leaching to determine a fertiliser recommendation that minimises nitrate losses whilst maintaining crop productivity. These are based on following these principles:

- Assess N fertiliser requirements in every field and in every year.
- Consider modifying planned nitrogen use if unusual weather or crop growth occurs.
- Avoid any temptation to be generous with nitrogen fertiliser.

4.6.3 SUNDIAL-FRS

SUNDIAL-FRS is a management tool and aims to provide farmers, growers and advisers with information on the nitrogen fertiliser requirement specific to a particular crop, field and year, so as to minimise pollution whilst achieving the desired yield.

SUNDIAL-FRS has been developed from the dynamic nitrogen turnover computer model SUNDIAL developed at Rothamsted and funded by HGCA (Bradbury et al. 1993). SUNDIAL, the research tool is used by scientists to interpret the results of field experiments, in particular the effects of crop management, soil type and different weather patterns on nitrate leaching. Under MAFF funding the research model was developed into an FRS, a PC based version for growers (Smith et al. 1997). It has a windows-based menu-driven interface, through which the user can enter information, run the model and receive advice (Smith et al. 1997). The extract in Box 4.5 from the Rothamsted Research website describes how the tool works.

Box 4.5 Extract from Rothamsted Research web site (Rothamsted Research 2004)

<u>SUNDIAL-FRS</u>

SUNDIAL-FRS will provide fertiliser recommendations for most annual arable and some horticultural crops commonly grown in the UK, growing on all the common arable soil texture classes (sand, clay, etc) with the exception of organic soils (peat etc). The recommendations can be applied with confidence to all the major arable and horticultural areas in England and Wales for most common management practices. The provision of accurate, site-specific fertiliser recommendations is difficult, because of the many complex, interacting processes which make up the nitrogen cycle. To assess how much fertiliser a crop requires SUNDIAL takes account of the supply of nitrogen from the soil, from incorporated crop residues and from organic and inorganic amendments of N to the soil. It also considers the crop's ability to extract nitrogen and losses of nitrogen over the growing season. Each process influences all the other processes in the cycle, and is subject to year to year variability in weather conditions.

SUNDIAL is an improvement on other systems because they need measurements of soil mineral nitrogen and crop nitrogen, and use static models with standard relationships of nitrogen availability to predict nitrogen requirements under 'normal' weather conditions. They cannot account for year-to-year variations in the weather or provide accurate recommendations for the timing of fertiliser applications. Whereas SUNDIAL takes full account of soil conditions, cropping history and local weather data to provide a fertiliser recommendation specific to the current crop, soil and season.

<u>Using SUNDIAL-FRS</u>

SUNDIAL FRS requires the following information about each field as input data: the soil texture class, previous cropping and management history, the current crop type, together with its sowing date and expected yield. It runs on a weekly time-step, using weekly rainfall, evapotranspiration and average air temperature as meteorological inputs. The expected yield of the crop (usually determined according to the farmer's knowledge of the field) is used to generate the crop nitrogen requirement.

To provide a fertiliser recommendation for a particular crop, the model is run with the field information and local weather data from prior to the harvest of the previous crop until the week when the fertiliser recommendation is required (probably during February or March). The model simulates the potential soil nitrogen supply and any losses of nitrogen over the remainder of the growing period, using a meteorological file generated from long-term data. It then calculates the additional fertiliser needed to achieve the crop's nitrogen requirement. SUNDIAL can be run for a number of years so that the cycling of nitrogen can be examined through various crop rotations.

SUNDIAL is not a crop growth model and requires an estimate of the expected yield of the crop before it can make a fertiliser recommendation. SUNDIAL-FRS includes a comprehensive range of 'default' values, for expected yield and other inputs. Adjustments are made to the expected yield according to region, and, for cereals, due to position in the rotation and sowing date.

(Note: 'Fertiliser' refers to inorganic nitrogen fertiliser).

4.6.4 Developing SUNDIAL-FRS: consultation with advisers and farmers

A central element of the project was consultation with farmers and advisers about the requirements of the FRS with the aim of 'formalising these requirements into a system prototype' (Smith et al. 1997:1). The process and results of this consultation were published as an article in *Soil and Use and Management* (Smith et al. 1997). The Association of Independent Crop Consultants (AICC) played a key role in linking the Rothamsted researchers both to advisers[52] and farmers. Interested advisers were 'recruited' and paid a fee for their involvement. They were asked to identify potential users of the FRS, that is, farmers actively engaged in improving efficiency and productivity on their farms, who would be willing to be consulted. Farmers were interviewed in groups or individually by researchers with their adviser present; the interview consisted of a demonstration of the SUNDIAL-FRS prototype current at the time, a questionnaire and a detailed discussion. The questionnaire provided information on:

- the range of participants and their farming practices (to ensure that cross section had been included);
- what PC hardware was in use on farm;
- the farmers requirement of the FRS (entry of input data and presentation of FRS recommendations); and
- the availability of on-farm data to run the model.

Analysis of questionnaires from 88 participants and discussions revealed farmers requirements of the FRS (Smith et al. 1997). These are described in detail in the paper, but in summary farmers requested that:

- entry of input data to be quick and easy;
- all input data be included as default values;
- a menu system with visible tree structure;
- FRS should provide recommendations for the whole farm;
- FRS be compatible with other farm recording packages;

[52] The term adviser is used here synonymously with crop consultant and independent agronomist.

- data could be entered in chosen units (only 57% farmers used SI units);
- fertiliser recommendations be presented as a simple prescription; the user should be able to select criteria for the recommendation such as maximum allowable nitrate leaching, maintenance of soil organic matter (SOM) or achieving a specific crop quality;
- the amount of fertiliser be expressed only to the accuracy of the fertiliser spreader;
- static or animated flow charts representing N dynamics be included (57% farmers expressed an interest in this); and
- organic manure application recommendations be included (48% farmers wanted this).

In addition it transpired that:

- although most input data is available to farmers, local weather data is frequently unavailable;
- <50% farmers were able to provide information on amount, timing and type of manure; and
- farmers had difficulty in making predictions of expected yield.

Based on questionnaire responses, researchers adjusted the prototype then returned to the practical community with the first version of the FRS. Meetings were held at Rothamsted where farmers and advisers were invited to review updates and contribute feedback. Advisers had the opportunity to feedback to researchers, both their own and their farmers' comments, throughout the project. Advisers were also individually sent uptakes (periodically so as to avoid confusion) of the model and those most interested kept in close contact with researchers. Version 3 had been developed at the time of this study. Parallel trials of farmer fields to validate the model were also carried out in a 3 year LINK research project.

MAFF funding terminated in 1999 at which point the researchers were diverted into other contracts or posts. Discussions about developing the business side of the model became protracted partly because of Rothamsted inexperience in these matters and funding issues. At this point the final FRS tool for farmers was still unfinished and there was no further funding available to make the adjustments farmers had requested. At the time of the interviews in 2001 the researchers involved were still committed to the research and were hopeful funding would be provided to finalise the FRS and create a useful tool.

4.6.5 Relevance to this research

Advisers had a role in this project both as gatekeepers between the research and practical community and as FRS evaluators. The case study therefore offers insights into advisers' interfaces with research and farming actors and their skills in using sophisticated tools. It represents a different way of approaching knowledge exchange about best management practice than the other two case studies, through using a highly technical decision model as a management tool. The target users of FRS will be restricted to competent and interested advisers and the more progressive growers seeking to maximise efficiency.

4.6.6 Methods and selection for interview

As this was a retrospective study, there was no opportunity to attend any meetings; methods were therefore confined to interviews. There was some difficulty both in tracking down advisers and farmers involved and prompting their memories about their involvement but this did not prove to be insurmountable. Sampling for interviews was restricted mostly to project participants, although opportunities were taken to question participants in other case studies about SUNDIAL-FRS and more generally about the use of models.

For interviews inside the project ten AICC advisers consulted were interviewed (Table 4.11). Selection for interview was based on those listed as co-authors in the paper published (Smith et al. 1997) and sampled on basis of advisers' depth of involvement and their willingness. Although listed as co-authors some had only attended meetings but shown no further interest in the FRS whilst others had been quite heavily involved and were still receiving updates. All three researchers involved in project were interviewed. Of the researchers involved, two remained at Rothamsted one had moved to another post. Three farmers who tested SUNDIAL-

FRS were interviewed. Although 88 farmers had completed the Rothamsted questionnaire it transpired that very few had tried the FRS or been involved in its further development.

Table 4.11 Interviews with those involved in the SUNDIAL-FRS project.

RESEARCHERS	
X	Rothamsted
Y	Rothamsted
Z	Rothamsted
INDEPENDENT ADVISERS	
EB	
PT	
PS	
CH	
AL	
N	
FARMERS	
Farmer W	Cereal farmer – Herts
Farmer A	Cereal farmer –Yorks
Farmer M	Cereal farmer – Lincs

For interviews with those not involved in the project, three researchers who had evaluated other models were also interviewed (Table 4.12). In addition various interviews were undertaken with advisers as potential users of FRS but who were not involved in project.

Table 4.12 Interviews with those outside the SUNDIAL-FRS project.

RESEARCHERS	
Academic researcher	Glasgow University
Research agronomist	ADAS
Research agronomist	Morley Research Centre

Chapter 5

ADVISER-RESEARCHER INTERFACES IN THE CONTEXT OF SOIL BEST MANAGEMENT PRACTICE

5.1 Introduction to the results chapters

The three results chapters are structured to explore different dimensions of the interfaces at which advisers operate in the context of soil best management practice in England. Chapter 5 is concerned with the interfaces between advisers and the research community; Chapter 6 explores adviser interfaces both with researchers and with farmers while Chapter 7 focuses on adviser-farmer interfaces. Chapters 5 and 7 specifically focus on advisers' interfaces with research and practice respectively, whereas Chapter 6 provides an overview of all adviser interfaces in recognition that interfaces, and the knowledge processes that cross them, are not separate entities but in reality continuous. The presentation of results draws on both the questionnaire and the case studies and as such provides insights into the processes operating across both institutional and social interfaces, thereby setting the results within the actor-oriented AKIS framework detailed in Chapter 3. Chapters 5 and 6 combine an analysis of patterns of knowledge acquisition and utilisation (which describe institutional interface processes within the AKIS framework) with a more in-depth exploration of advisers' interactions with researchers and farmers across social interfaces from the actor-oriented perspective. Chapter 7 is concerned principally with the social interfaces between advisers and farmers, looking at how the nature of the advisers' relationship with farmers affects the movement of knowledge about soil, and the implications of this for the advisers' role in facilitating sustainable soil management.

5.2 Chapter introduction

Chapter 5 is concerned with advisers' interfaces with the research community. It is presented in two main parts. The first (sections 5.3 and 5.4) is concerned with knowledge processes across institutional interfaces providing empirical data on the advisers' acquisition of knowledge from the research and policy community within the AKIS framework. Using the questionnaire analysis it describes the linkage mechanisms, preferred information sources that advisers use and the networks in which they engage to obtain information about soil best management practice. In describing these patterns this section provides an overview of the AKIS framework in terms of what constrains and enables knowledge processes. This is the main theme of the summary, which concludes this first part. The second part of the chapter (section 5.5) describes the adviser-researcher interface in the context of the SUNDIAL-Fertiliser Recommendation System (FRS) case study. It goes beyond the descriptive framework of the AKIS and its institutional interfaces and extends the discussion into a more in-depth analysis of the processes advisers engage in across social interfaces. Section 5.6 completes this second part of the chapter by presenting a summary. The chapter is concluded by a discussion of all the results and their implications for advisers' facilitation of sustainable soil management.

5.3 Advisers acquiring knowledge generated by the research community

Advisers obtain technical and scientific information about soil best management practice using a number of different sources and mechanisms. This section describes how access to information is enabled or constrained by formal linkage mechanisms and networks comprised of informal interactions, and how advisers develop their own individual strategies for accessing information. It also demonstrates how the advisory community value information and is committed to obtaining it from a rich and diverse range of sources. This suggests a community generally striving to be well informed about soil management research outputs.[53]

Advisers use two sorts of mechanisms to access information about soil management generated by the scientific community: formal linkage mechanisms organised by

[53] Chapter 3 discussed the distinctions made between information and knowledge in the AKIS. This chapter understands that advisers access information using devices such as texts, data, models and language but internalise these, adding them to their stock of knowledge. They therefore access information but through this acquire knowledge.

institutions intended to disseminate information (described in 5.3.1); and the less formal, often personal, interactions that reinforce and extend these formal mechanisms creating networks (described in 5.3.2). Conceptually these formal and informal mechanisms represent the linkages between communities and actors across intuitional interfaces in the AKIS.

5.3.1 Linkage mechanisms between advisers and the research community

In terms of linkage mechanisms advisers use formal dissemination events such as workshops, demonstrations, training and publications like journals, newsletters and bulletins to obtain information. These are provided in the main by the research, policy, advisory and trade communities and used extensively by advisers to keep up to date with research, product development and policy. Table 5.1, derived from the questionnaire data, shows the mechanisms different adviser types rated as most important for getting research information about soil management. Training was valued by all advisers as were conferences and workshops and technical bulletins, particularly amongst agronomists, while journals were less popular and demonstration farms and agricultural shows were rated relatively poorly by all adviser types.

A large number of advisers from all sectors have undertaken training in soil best management practices (Table 5.2); this suggests a strong interest in accessing information from research sources. Agronomists are increasingly required to train in environmental practices both to obtain CPD[54] points for FACTS and to be able to meet more challenging farmer requests. This is thought to have the effect of raising standards throughout the profession. Although soil management training is not given *per se*, it is integral to: the FACTS courses which stress efficient fertiliser use in the context of soil nutrition; to the training provided by ADAS to deliver DEFRA's tools such as RB209 and MANNER; and training courses on the efficient use of manures and the control of erosion. Advisers attend a range of training courses run by ADAS, LANTRA, ARC[55], and NGOs as well as in-house courses within commercial firms

[54] Continuing Professional Development. Advisers registered with FACTS have to undertake training to maintain their FACTS registration. The curriculum is provided in Appendix 1.
[55] Arable Research Centre (ARC) has since changed to The Arable Group (TAG) following a merger with Morley Research Institute.

Table 5.1 Mechanisms advisers use to keep up to date about soil management research.

	Adviser type % respondents					
MECHANISM	Conserv-ation	DEFRA RDS	Independent agronomist	Distributor agronomist	ADAS	All
Training course	64	75	69	58	39	63
Personal contacts: advisers	48	50	45	23	70	48
Conferences/ workshops	35	35	65	61	48	43
Internet (DEFRA)	26	75	29	46	78	43
Technical bulletins	42	45	42	38	39	42
TIS (FACTS)	16	10	57	61	30	40
Farming press	58	45	29	38	35	38
Personal contacts: researchers	26	15	40	15	43	33
Personal contacts: farmers	48	30	29	38	13	31
Scientific Journals	19	25	36	31	36	31
Demo farms	19	10	16	15	26	18
Newsletters	19	15	14	15	22	16
Agricultural Shows	16	10	11	7	0	10

Table 5.2 Advisers undertaking soil best management practice training.

	Adviser type % respondents				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Relevant Training	77	80	90	69	81
FACTS registered	12	34	79	100	87

and consultancy groups. Results from the questionnaire show a high commitment to FACTS registration (and therefore FACTS training) amongst the arable sector, notably distributor agronomists, but this is understandably lower amongst conservation and RDS advisers.

Effectiveness of linkage mechanisms

Advisers made negative comments about the effectiveness of research in terms of the poor state of linkages between the research community and advisers and farmers. The gap left by the privatisation of ADAS was mentioned by a number of interviewees who had no clear view as to who should fill it and there was a general sense of inertia mentioned by several advisers. There was an impression that research results were not reaching the practical community, as one independent agronomist (PT) lamented '*I just wish they [the researchers] could get more of the information over to farmers, probably by dealing with us a bit more*'.

Questionnaire results suggest that the mechanisms for the dissemination of research results on soil management are failing. The majority of all questionnaire respondents (66%) thought that poor contact between research community and advisers limited the effectiveness of research on soil management (Table 5.3). More distributor agronomists (80%) found this limiting than any other adviser type, although this does not concur with results presented later in Table 5.6 which suggested that they find research institutes to be an important source of information.

Transforming theoretical ideas into practical applications is seen to be hindered by a lack of connection or what some called a 'gulf' between the research and the farming community. Advisers describe research as 'off target' and criticise researchers for not understanding the pressures farmers are under in farming that mean soil best management practices are not always possible, as one independent agronomist (Q) remarked, '*Researchers need to understand the physical demands of agri-business to know why their well intentioned advice often has to be ignored*'. Although fewer questionnaire respondents recognised practical use of research as limiting.

Table 5.3 Adviser views on limitations to the effectiveness of research on soil management.

	% respondents		
Limiting factors	Not limiting	Don't know	Limiting
Poor dissemination of results	9	26	65
Poor contacts between the research community and advisers	14	20	66
Research is of limited practical use to farmers	49	20	31

A number of other problems with the effectiveness of soil best management practice based research were also identified, associated with funding, direction and continuity. The direction and co-ordination of research is seen as a big problem by some advisers, as is the nature of short-term contracts. This was particularly demonstrated in the SUNDIAL-FRS case study where a finite contract was blamed for lack of effectiveness. Advisers are well aware of the demands short-term research funding puts on institutes, as this independent agronomist (LS) observed '*It depends on continuity and that's exactly what you don't get in any of these research places now*'.

Advisers' opportunities to inform research and the effectiveness of feedback were also considered. A small number of advisers are engaged in research through trials and demos, or are very active in publishing and presenting at conferences. They might also be involved on expert committees or panels, liaising closely with research institutes and personnel, validating models, or undertaking higher degrees. In terms of adviser association with organisations that conduct research the questionnaire data (Table 5.4) reveals that relatively high numbers of both distributor and independent agronomist respondents work for organisations that conduct research and therefore should have opportunities to interact with, and provide feedback to researchers. The data also show that distributor agronomists (42%) had most input into research compared to independent agronomists (19%) and ADAS (30%). There was some indication, however, that advisers did not always use the available opportunities for linking with research, for example, advisers' membership levels of ARIA, a friends of Rothamsted group for growers and consultants, were disappointing according to researcher interviewees.

Table 5.4 Adviser involvement in research.

	Adviser type % respondents				
	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Organisation conducts research	25	100	30	38	95
Input into agronomic/ soil research	6	14	19	42	30

In terms of feedback, more formally advisers are included on research review panels and committees and can feed back farmer comments through this mechanism; they would also use any events where they interacted with researchers such as training, workshops, conferences, demo farms, and trials sites, and less formally through personnal contacts. Some advisers, however, do feel excluded from some areas of research, as one very experienced independent agronomist points out:

HGCA review projects through various committees and there is dearth of agronomists on committees. There are farmers, grain trade, UKASTA but we are the main players and excluded. There is practical input coming from farmers and very good farmers but I'm not convinced that farmers can do such a good job as some agronomists (Independent agronomist LS).

Some researchers interviewed regard contact with advisers as beneficial, as they inform the research community on practical issues, support the research work and give feedback from farmers. This feedback is passed on to and valued by researchers within the agrochemical supplier/manufacturer community as well. Researchers particularly value the breadth of advisers' experience and client base. A trials officer for a distributor firm explains:

Agronomists have between 15-100 farmers, they are ones seeing these different situations and talking to farmers on a daily basis, as well as the open days and some questionnaires they send (Distributor trials officer).

The questionnaire data suggests that ADAS advisers (70%) have most opportunity to feedback farmers' reactions and ideas about agronomic/soil research to researchers but nearly half of independent agronomists (46%) and distributor agronomists (41%) have opportunities. Conservation (29%) and RDS (27%) advisers have less opportunity to feedback to the research community.

In terms of influencing the direction of research and policy through feedback advisers consider that they have a very limited role. Some project advisers have to be manipulative and write research proposals that can meet their own agronomic needs but appear to meet the other policy objectives as well, but opportunities are limited as this comment reveals:

For all the environment stuff I do it's policy driven regardless of the agronomists and what they want, the headline issues get the money. You can sometimes reconcile the two, environmental protection policy and farmer needs, but ultimately you go for where you can get the money (ADAS adviser C).

5.3.2 Advisers networking with the research community

The linkage mechanisms described above are underpinned and reinforced by the extensive informal and often personal connections that advisers forge with other actors in the AKIS. Together these create networks, or patterns of communication and interaction among social actors who share a common concern (Box 1989). Whereas formal linkage mechanisms are used by advisers primarily to access information from the research community, informal linkages connect advisers both vertically with researchers and horizontally with other advisers. The number of advisers in the agricultural community is small and so there are many opportunities for informal interactions. Consequently the scope for extending networks is great. As an independent agronomist (RB) remarked '*There's quite a close knit group of advisers and researchers involved in agriculture, you do tend to see the same old faces*'. Advisers are active in combining formal linkage mechanisms detailed above and these less informal links to cultivate extensive networks both horizontally within the advisory sector and vertically with the research, policy and trade communities. They consider this as necessary to fulfil their job, to keep up to date both with technical and policy information and with industry news as a whole, and to provide opportunities to expand their client base. The value and necessity of communicating with as many people as possible is recognised and being proactive in seeking out information is seen as essential to operate as a 'good' adviser. Informal connections flourish where advisers have a common objective and where they perceive mutual advantage of the connection. Conversely competition, secrecy and different objectives inhibit linkages. Vertical and horizontal adviser networks are discussed separately below although in reality this distinction is more blurred.

Adviser vertical networks

Advisers employed by larger companies such as distributor agronomists, consultants and farm management company advisers' benefit more from strong in-house formal and informal linkage mechanisms than independent advisers, as a distributor agronomist (RW) commented '*It's quite a small world, most of my meetings would be colleagues within the company. It's very much internal*'. Distributor and larger consultancy firms have their own technical research teams in house and trials officers see it as part of their remit to attend conferences and keep up to date and then feed research through to their advisers. Also, with the decline in opportunities for direct contact between manufacturers and farmers, manufacturers are relying more on distributor agronomists as their link to the farming community. The larger distributors, because of their considerable purchasing power, increasingly have more influence over manufacturers. A distributor agronomist (RW) remarked '*Distributor agronomists can screw information out of the manufacturers a lot more effectively, whereas if you only have three agronomists it would be very difficult to get*'. Information exchanged within manufacture and distributor companies, however, will inevitably be more focused on use of agrochemical products, often to the detriment of learning about soil management. Obtaining information about non-chemical issues is difficult for distributor agronomists, one (GB) explained '*I'm kept very well up to date on agrochemical side of things but for cultivation and establishment I'm really trying to grab information from any place I can*'.

However, larger firms, by virtue of their contacts and their resources, also provide easier access for their advisers to certain research organisations enabling them to create and extend their networks further. For example, this occurs through company membership of MGA and ARC, SMI, and through research collaboration such as LINK projects. Consultants in larger consultancy firms also benefit from the firms' greater networking capacity. The firms are described as being more 'in the loop' than smaller or more specialised organisations. They need to keep up to date with policy and regulation, they respond to government consultations like the Draft Soil Strategy, they run training programmes for the adviser community and undertake large contracts for organisations like the Environment Agency. Advisers from these high-profile firms tend to get invited to contribute to expert panels and research review committees which provides another mechanism for contact with the research community. This is an important device for keeping up to date, for example, one consultant (TL) said '*I sat on the RB209 rewrite committee last year and doing things like that I keep up to date automatically, talking to contemporaries*'.

Independent agronomists in contrast do not benefit from the infrastructure nor the connections and formal linkage mechanisms of larger organisations, but have to establish their own personal connections to extend their networks. Obtaining information is described as becoming increasingly difficult and they struggle to keep up to date, particularly as conferences and training are costly and time consuming. ARC is valued as a source of impartial information but advisers are charged a higher membership because, as one independent agronomist put it, they are seen as potentially '*wholesaling information*'. Whilst distributor firms can afford this, independents cannot. Consequently independents make great efforts to talk to everybody and become members of relevant organisations. Independent agronomists have to go to great efforts to maintain their information sources. A farmer (AF) pointed out '*All agronomists are members of as many groups as they can afford to be*'. Some independents also find that by working in teams they benefit from expanded connections, for example, one explains:

I work in a team of 5 although we're all self employed. We're involved with all major manufacturers of agrochemicals and fertiliser, a member of Morley, member of ITCF, go to as many ADAS meetings as invited to, go to all major demos and in house trials and through Consultant X who has an extensive trials programme. We go along to HGCA, not that we support them, but it's increasingly difficult (Independent agronomist RP).

Professional bodies are particularly important to independents to keep up to date about research and policy. The AICC and BIAC are most active and bring together a large number of independent advisers and consultants both nationally and regionally by providing meetings, visits and training programmes. The value of these associations is shown clearly in the questionnaire data with 49% of independent agronomist respondents rating them as an important mechanism for accessing information (Table 5.1). These associations are seen as critical in maintaining contacts and lines of communication for the otherwise 'infomationally starved' independent agronomists.

We started AICC 23 years ago and it has grown in numbers and influence establishing good relations with a whole range of organisation, research stations, fertiliser manufactures etc. We also have training days, conferences and courses. It's not so important for me because I have established contacts, but for fully independent agronomists it is vital (AICC founding member; Independent agronomist PT).

Growers and consultant groups run by Long Ashton, HRI, Rothamsted (ARIA), IGER and HGCA (Agronomists Alliance) also provide opportunities for technical and social exchange with researchers as well as other advisers and farmers. Conservation advisers appear to have better connections with researchers than distributor agronomists and RDS advisers (Table 5.1).

However, despite these efforts to maintain connections, secrecy and lack of awareness can contribute to poor knowledge exchange and deficiencies in networks were exposed. For example, many farmer-funded organisations like ARC and distributors/farm management companies are protective of the exclusive trial information they provide to their farmers. Since farmers pay for the privilege of getting this information the associations are obliged to keep it exclusively for them. Even membership does not always guarantee access to resources because of a general climate of secrecy.

We're members of the Maize Growers Association (MGA) but we're not necessarily supporters of MGA I have to say, because they are very protective about the *information they gather and they don't necessarily want to share it* (Distributor agronomist RB).

Other gaps in the networks were revealed. For example, ancillary industries like merchants appear not to be on DEFRA's mailing list for environmental protection literature. This represents a significant omission as many of these organisations are key players in the advisory industry. Many individual agronomists also complain of being 'out of the loop' for a lot of environmental information. They recognise they have a role in promoting best management practice but feel excluded from many projects and argue that their views are not sought. Some very informed agronomists working in the Landcare catchment, although aware of soil wash problems, were unaware of the Landcare project and its objectives. They explain that they feel excluded from such initiatives. There is also a fear that such projects do not recognise the work that advisers already do and that they may be duplicating efforts, as these comments from distributor agronomists reveal:

They don't bring advisers into the loop enough. There could be more bridges built and more working together; there's expertise on both sides. The Environment Agency wouldn't have that good a knowledge about how agronomy works and soil management, the advisers wouldn't have knowledge on potential contamination and other water issues that the Environment Agency have. There's mutual interest, bridges could be built and bring something together (Distributor agronomist GB).

There is always a danger with those types of groups if it's not inclusive, they are reinventing the wheel, they may find the problems are not problems at all and people are already working on it (Independent agronomist JC).

Adviser horizontal networks

Although networks are reinforced when advisers perceive a mutual advantage to sharing knowledge, secrecy and competition can equally inhibit connections. Competition is greater on the commercial side between distributor agronomists and can lead to weak links between these organisations. One distributor agronomist (RB) observed '*Yes there would be competitors out in the field trying to steal our business and we're trying to steal theirs. They differ in their philosophy; some will be more* *arch rivals than others*'. Links between independent and commercial agronomists are also constrained by competition, although they might encounter each other regularly and be on first name terms. Competition within the non-agronomy community, although it does exist for clients (for example FWAG and GCT) and for funding sources, does not appear to inhibit overall networking. They belong to a small community and advisers have good professional and personal connections with other advisory services, as the questionnaire data shows (Table 5.1).

In terms of cross community adviser links, traditionally advisers from agronomy and non-agronomy communities have limited contact mainly because they are aware that they are providing a different service.

There are two sorts of adviser going onto farms, the FWAG type talking about hedges and the agronomist talking about soil/fertilisers, they don't cross over but stay to their particular area because they know they are offering different advice (Independent agronomist SD).

However, as environmental protection and best management practice advice are becoming more integral to day-to-day arable practice, some independents are becoming active within certain non-agronomy networks, for example, they may be contracted to the Environment Agency or provide FACTS training to FWAG. Increasingly initiatives like SMI and Landcare encourage membership from both communities. These alliances are a function of the more diverse and flexible AKS described in Chapter 2. Cross community links are improving as mutual benefit to all parties is realised. Good links between FWAG advisers and agronomists, for example, provide a chance for both to reach a new client base and for agronomists to keep up to date with environmental policy and regulation. The mutual benefits are highlighted in the following FWAG adviser's observation.

Certainly we have a very good relationship with a number of agronomists whether they be independent or from companies like Masstock etc. We do work reasonably closely, they would come to events, give talks about things, pass their clients our way. They're a good source of information and once the relationship is there they are happy for us to come in and talk about things from our perspective to their *clients. Independent agronomists like to keep in contact with us. Agronomists need to know what's in the pipeline, we have DEFRA's ear, yes they see us as an important part of the whole picture* (FWAG adviser A).

Advisers' reliance on personal contacts

Personal contacts are very important for accessing information and are used where more official routes are ineffective or not established. Table 5.1 shows that for most advisers personal contact is the second most important mechanism of obtaining information after training and is more important than other more formal mechanisms. Personal contact is particularly important for independent agronomists who often use former colleagues as a source of information.

When I was in ADAS and Scottish Agricultural College (SAC) the lines of communication were always established but when I became independent I had to establish my own lines of communication. I called in old friends (Independent agronomist LS).

A lot of independent agronomists are ex-ADAS and they ring up for advice. You can't say no, well I can't, they are friends. A lot of the guys I know very well and I have strong contacts with them, although ultimately my ADAS consultant colleagues do compete with them (ADAS adviser).

Some individuals are more proactive than others and exploit personal links with trade and research organisations, for example, one independent agronomist (AL) admitted '*I shamelessly use the people at Rothamsted to get information*'. These personal contacts are important as other sources are becoming progressively more guarded. The questionnaire data demonstrates that independent agronomists value personal contacts with advisers and researchers more than distributor agronomists do to keep up to date about soil management research (Table 5.5). Table 5.5 also demonstrates how personal links, particularly with other advisers, are used widely, most notably by ADAS advisers.

Obtaining information is described as getting increasingly difficult as the industry as a whole, whether research institutes, trade, or farmers research groups, are becoming more protective. This, together with the problems of keeping up to date through formal mechanisms like the research journals and reports, explains why many advisers prefer personal contacts, which they see as quicker and more effective. Advisers also find it hard to track down information, particularly from the academic community, as these comments demonstrate:

It's person to person, they are the best contacts particularly for my new job, because research is often reported in something I may not read, or it may be published in a journal years after it has been completed. I don't trust the system, I do scan through some journals but I see it as a safety net, by the time it's got there if I haven't heard about it then I've failed (ESA Project Officer A).

We know the work [on diffuse pollution] has been done by x university, or x PhD student but it's very difficult to track it down, you are aware that you're reinventing the wheel and the work's been done...it's hard to find relevant stuff without personal contacts to universities (FWAG adviser A).

Table 5.5 The importance of personal contact as a source of information about soil for advisers.

	Adviser type % respondents					
Personal contacts with:	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS	All
Advisers	48	50	45	23	70	48
Researchers	26	15	40	15	43	33
Farmers	48	30	29	38	13	31

Some advisers are also very active in building networks with the farming community both to expand their client base and to exchange information. They do this through joining farmer discussion and research groups like the Chalkland Cereal Group in Wiltshire, growers groups run by research institutes, attending farmer meetings and demonstrations and generally building up good social relationships with their clients.

Although advisers value farmers' practical experience, the questionnaire data suggests that a surprising number (average 31%) also use farmers as a source of research information about soil management (Table 5.5). Some more progressive farmers are, however, becoming more protective about the knowledge they generate and are not always happy to share it, particularly knowing that advisers will repackage it for another farmer's benefit. One farmer interviewed who runs a farmer research group, expressed reluctance about an adviser becoming a member for this reason.

5.3.3 Preferred sources of research outputs

Different adviser types exhibit clear preferences for different sources of research information (Table 5.6). The high value given to DEFRA/ADAS as a source by ADAS and RDS advisers reflects the strong links within the government and ex-government community. Independent and distributor agronomists value the FACTS Telephone Information Service (TIS), which is intended to support commercial agronomists; farmer funded research organisations like ARC and Morley; and research institutes more than other advisers do. Although distributor agronomists (23%) valued information from agrochemical companies more than other advisers, they also use HGCA, ARC and research institutes. AICC was valued highly by independent agronomists. All advisers rated the farming press relatively highly. The non-agronomy community find the farming press, DEFRA/ADAS, the Environment Agency and other advisory services the most important sources. The low value given to farmer funded organisations and agrochemical companies suggests that, as expected, these sources are outside their normal networks or sphere of interest.

Different adviser types value different sources, which reflect their accessibility and perception of credibility, partiality and usefulness and the networks that the advisers operate within. Interviews revealed some of the details behind these preferences such as the range of information sources open to advisers, the strategies used by different advisers to gain information and identify acceptable sources, and the suspicions and preferences which the advisers are guided by. Finding impartial information is a priority for many agronomists, as a distributor agronomist explains:

Yes there is a spectrum everybody will get the information from whatever sources are more acceptable to them. Some agrochem firms provide good information, some are suspicious. You have to look towards independently run trials and run them off *against each other, it depends whether you see through the spin* (Distributor agronomist GB).

Table 5.6 Sources advisers use to keep up to date about soil management research.

	Adviser type % respondents					
SOURCE	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS	All
ADAS/ DEFRA	26	75	29	46	78	43
FACTS (TIS)	16	10	57	61	30	40
Farming press	58	45	29	38	35	38
Research institutes	19	25	44	46	30	35
BIAC/BASIS/AICC	0	10	49	7	13	26
Environment Agency	45	30	18	23	13	25
Other advisory services	23	30	22	15	4	20
Agrochemical companies	12	10	18	23	4	14
Soil Association	25	15	8	23	13	14
HGCA	0	10	25	38	13	18
ARC/Morley	3	0	36	38	13	12

Many favour traditional sources of research information, some appear to respect the soil research community, a number hold the Rothamsted researchers in '*pretty high regard*' and see the scientists they '*respect a lot*' as producing high quality research as one independent agronomist (AL) observed '*Rothamsted are so good it is one of the few truly scientific establishments left*'.

Advisers are aware that those producing results often have their own objectives, eg. DEFRA funded research emphasises environmental protection while near market manufacturer and distributor research will have a commercial agenda. Because of this some prefer farmer funded research organisations like ARC which produce independent research which has immediate relevance to their work, they see it as more practical and answering their needs, as one independent agronomist (DG) said '*I like the way they [ARC] work, the thing I like is they reach conclusions, they say look you should do so and so*'. Advisers value ARC's impartiality and feel if they do not subscribe to ARC they are heavily dependent on manufacturers. However, some even question whether ARC trials are independent when some trials are manufacturer sponsored, for example, one independent agronomist (DG) asked '*Would ARC come out and say a £50, 000 BASF sponsored trial has failed?*'

5.3.4 Advisers value research differently

The assumption of DEFRA's knowledge transfer policy is that once the research community produces information and makes it accessible to advisers and farmers it will be used to inform their advice and practice. Advisers, however, value information from the research community to different degrees, while some put great faith in it, others have concerns that the research outputs and associated research tools relating to best management practice are often too impractical to implement at the farm level.

Research outputs are appreciated by a number of advisers who regard research as the only sound basis on which to base their recommendations to their farmers. This view is commonly found amongst advisers from ADAS, independent agronomists who are ex-ADAS advisers and project advisers who tend to value more, demonstrate a greater understanding of, and participate to a greater degree in research. The comment below, for example, is from an ESA Project Officer who, because of his background and professional association with ADAS, puts a high value on research.

It's [research] vital. It's got to be a key driver for what I do. My view is from my old job [ADAS] and my new job is that I can't be credible unless I can be objective and I can't be objective unless I have research behind me. It's as simple as that, so from my point of view it's absolutely critical (ESA Project Officer).

However, some advisers do not consider research to be the answer at all for soil management problems due to the soils variability; instead they stress the importance of building up practical knowledge, one agronomist, for example, remarked:

The problem with soil in particular is that research is not what we're looking for. As you can see soils are varied, depending where you are on the farm, you have a different answer from experiments every time. We need funding to get basic practical knowledge. So research is not what we're aiming at (Independent agronomist SD).

Most advisers, however, appreciate the research work done to achieve tools such as RB209 which they see as essential and agree that is exactly what the government research should be helping to provide. Others are not quite so convinced about the value or relevance of soil management research and will only use it if results demonstrate a good basis for change. They do feel obliged to use research outputs if they clearly show that profitable cropping can be achieved which is sympathetic to the environment. They all stress the importance of sound research data and good resulting guidelines or tools. In short, they value research outputs that work in practice.

Agronomists also tend to be cynical about the emphasis on environmental protection, for instance they question the value of, and outputs from, large research programmes like the nitrates programme supported by DEFRA. These comments suggest that even where linkage mechanisms are effective advisers do not always engage fully with the information they convey.

5.4 Advisers acquiring knowledge generated by the research community: summary and discussion

Overall the data presented in section 5.3 describe an advisory community actively engaged in obtaining information about soil best management practice. Advisers use a wide variety of sources and mechanisms to acquire the extensive knowledge generated by research. Knowledge acquisition is central to how advisers from all communities carry out their work; they are proactive in acquiring it and see this as essential to being a 'good adviser'.

Advisers search out and value information in very individual ways and the preferred sources and mechanisms they use reflect their opportunities, resources, agendas, professional histories, and personal interests as well as how the advisers value and trust the source and their perceptions of partiality and validity. Advisers can be equally suspicious of the government's green agenda and the trade sector's commercial agenda. Advisers might show partiality towards certain sectors for information or demonstrate some standardisation by relying on the same channels. They prefer locally derived information such as from a local research station and are often very cautious in their acceptance of national figures and farming press advice.

Advisers from conservation, DEFRA RDS, agronomy, ADAS use different mechanisms and sources to acquire soil management knowledge. They interact with other actors in the system through networks created by formal and informal linkages, which cross-institutional and personal interfaces. The AKIS multi-actor perspective describes this complexity well and provides a framework in which to situate these actors and their multiple and varied interactions. It also assists in identifying factors that enable and constrain knowledge processes. Although advisers are active in acquiring knowledge across institutional interfaces the results confirm a degree of vertical fragmentation as identified by Winter (1995). A significant number of advisers consider that poor dissemination of research results due to poor links between the research and advisory community is making soil management research ineffective. Advisers value knowledge from the research community to different degrees, while some put great faith in this source, many have concerns that the research priorities do not reflect those of the practical community, further weakening the vertical integration of the AKIS. Mechanisms for advisers feeding back into the research community are not well established either and they rely to a large extent on *ad hoc* meetings and informal contacts. These appear to favour the advisers attached to more powerful and influential organisations and those like ADAS with a tradition of research, and inevitably exclude advisers who could make a valuable contribution. Figures suggest, however, that a relatively large number of advisers' organisations are involved in some research activities, which should enable some in-house feed back. Opportunities for advisers to influence policy and research priorities are very limited. Rigid short-term contract based research is considered by many to lead to further vertical fragmentation.

Horizontal integration is weakened by competition and secrecy, which prevents free exchange between agronomy communities. This reflects the pressures agribusiness in general is facing and the power relationships that exist in the AKIS. In terms of access to information within the AKIS, the domination and control by the larger organisations is evident. This power extends to providing training for large numbers of advisers, winning sizeable contracts, influencing research and policy, and establishing links with growers and research organisations. Agronomists recognise that bigger groups are more influential and are forming alliances and merging to increase their 'stake' in the community (Farmers Weekly 2003). Strong manufacture-distributor links contribute to a powerful trade sector in terms of holding and redirecting information. Independent agronomists are at a disadvantage as they are both excluded from such networks and lack the formal in-house support of those in larger organisations. As such, they must rely more on personal contact and their own associations. Poor vertical connections can result in some advisers, including merchants and contractors, feeling 'out of the loop' in terms of awareness of environmental information. Poor cross-community links also contribute to horizontal fragmentation within the adviser community although these are improving as all advisers see a mutual advantage to interacting.

The AKIS formal linkage mechanisms therefore, although well used, are insufficient to provide advisers with all the information they need. Instead advisers devise alternative methods for accessing information mainly through personal contacts. Faced both with overload, and with competition and secrecy they need to develop selective strategies for accessing, choosing and using information. By combining formal linkage mechanisms with informal personal links they cultivate extensive networks both horizontally within the advisory sector and vertically with the research, policy and trade communities. Individual adviser networks, and strategies for using them, create unique adviser portfolios of information. These results agree with those of Engel (1997: 126) who found that for advisers 'the professional communication strategies are an intrinsic part of their daily practice'.

Results have shown that advisers have the capacity to exploit enabling, and overcome constraining conditions and contrive different strategies. They negotiate their way around the limitations of the institutional AKIS by creating their own personal channels of communication; forming alliances, exploiting friendships or contacts and combining these with more formal mechanisms. These networks achieve a higher degree of integration than linkage mechanisms although arguably they may be more fragile. As van Crowder and Anderson (1997) point out the removal of one key individual can disrupt the whole chain. Although the value of personal networking has been recognised for farmers (Warriner and Moul 1992; Sobels et al. 1999), the importance of this to advisers has been somewhat overlooked. The networks they create and defend demonstrate that advisers can act as autonomous agents determining their own degree and extent of accessing knowledge from others. This is consistent with Engel's (1997) findings that 'to gain access to a range of options and insights advisers actively engage in building and managing interactive relationships with those they consider relevant'. Also these diverse and multiple connections create opportunities for advisers, as other researchers have noted, Engel (1990), for example, described the multiplicity, relative autonomy of actors and diversity of the AKIS as inherent qualities which might provide leverage points for effective knowledge management. Arguably a more open and fragmented AKS allows advisers to exploit opportunities for networking and informal linkage, thus confirming Winter's (2001 et al.) suggestion that a more flexible AKIS is also a more creative one.

This suggests that the open AKIS enables as well as constrains and that advisers must negotiate these opposing forces. It is also argued that even though segmentation, conflict of interest and environmental pressure are natural attributes of the AKIS, diverse and flexible systems are also potentially adapted to make fast adjustments to changes in demands and circumstances. Arguably the more flexible and expanded roles of agronomists and conservation advisers with regard to soil best management practice described in the results are evidence of such adaptations.

5.5 Different perspectives on research at the adviser-researcher interface: the SUNDIAL Fertiliser Research System (FRS)

Section 5.3 described the patterns of linkages across institutional interfaces through an application of the AKIS framework to develop an understanding of advisers' interactions with research. However, as hinted at earlier, advisers assign different values to research and as such these patterns may not provide a true reflection of their knowledge interactions. This section explores these interactions in more depth by referring to the SUNDIAL-FRS case study. Conceptually this investigation refers to the social interfaces between advisers and researchers which can provide an understanding of knowledge processes as social, not purely mechanistic, processes.

These results relate to the researchers' consultation of the adviser and farmer communities in developing the SUNDIAL-FRS, as described in Chapter 4. This case study provides some insights into the different perspectives about the usefulness of decision support systems (DSS) derived from research models. Despite sound research and the best intentions of the researchers and funders, problems have emerged which have impeded the translation of the SUNDIAL research model into a practical FRS. Advisers blame the FRS limitations on researchers' academic interests, often erroneous assumptions, fundamental problems of using a spin off from research, lack of understanding of practical farming and failure to incorporate feedback. However, from the researchers' perspective they have a sound model and have made genuine efforts to consult farmers and to provide a useful and much needed FRS. They attribute problems, in part, to the advisers' and farmers' lack of understanding of models but predominantly to research funding constraints. These two perspectives are explored in detail in the following sections.

5.5.1 Adviser perspectives on the development of SUNDIAL-FRS

<u>Limitations of model spin offs</u>

One of the key issues identified by advisers in explaining difficulties associated with the FRS was the fact that it was a spin off from the SUNDIAL research model, which has been developed and used as a research tool at Rothamsted. Farmers and advisers alike recognise that there are inherent problems in changing a research model into a farm decision support tool. It was felt by some that researchers who develop models are often more interested in the academic pursuit than any practical outcome, as these comments suggest:

Research institutes setting up PC programmes, they are more interested in the programme than the commercial use (Independent agronomist N).
It's very difficult to try and constrain people of the scientific ability they have got at Rothamsted to looking at things that are specifically oriented to farm advice, because it doesn't always happen (Farmer W).

Science models answer a lot of important questions for scientists but not necessarily for farmers, they have to be regigged to be useful (outside researcher).

Because of these academic origins such FRS are thought by some to neither contribute towards science nor to practice, indeed one commentator from the research community described the SUNDIAL-FRS as '*falling between two stools*' being neither an adequate research model nor a practical farm tool. This is reflected in comments made by advisers about the recommendations from the FRS. Some were surprised that despite the extensive research work and evaluation done at Rothamsted the model didn't seem to '*hit the spot*' when it was used at the farm level.

Other criticisms focused on the fact that the idea for the FRS came from the researchers themselves in response to funding opportunities from DEFRA rather than from the farming community, although the advisers did accept it was addressing a real problem (see Chapter 4). Fundamental concerns were also voiced by advisers such as lack of expertise in programming and commercial development within the project. They respected the researchers at Rothamsted as trained chemists and soil scientists, describing them as '*very good people, very keen and nice*', as one agronomist (LS) remarked, but pointed out that they were not professional programmers which slowed down progress considerably because of the inevitable software glitches.

Different understanding of models

Researchers, advisers and farmers have different levels of understanding of the limitations of models and different levels of confidence in their outputs. Some research modellers have great faith in their models refusing to believe they are infallible. One modeller (not involved in the project), for example, when told that his model had failed to predict field results, argued that the field results (i.e. 'reality') were at fault not the model. Conversely some advisers question the validity of research data underpinning the models, for example, one independent agronomist (AL) said '*The history of models in agriculture has not been good. I discovered Rothamsted were using models that were kicking around in early 80s which were as flawed then as they are now*'. Most advisers, whilst they appreciate the research work behind the model, recognise the inherent limitations of models, that is, that they are only as good as the research data used to build them. Even when the models are well developed some view them as having limited application because they are desk based rather than field based, at best advisers perceive them as just another tool at their disposal:

We used SUNDIAL for what it was intended, to try it out. It came up with some recommendations and we utilised it, but I do think it was like a lot of technology, it's only a tool and I'm not sure it was as helpful as it might have been (Agronomist B).

Assumptions made by researchers

Advisers criticised the researchers involved as too academic and lacking connection or understanding of day-to-day farm management issues and farmer priorities, as these agronomists' comments demonstrate:

There was obviously a great gulf between research scientists and the practical community, a far greater gulf than I had hitherto been aware of (Independent agronomist LS).

The Rothamsted staff involved [in SUNDIAL] were real researchers; they had no idea what it was like to go into the field (Independent agronomist EB).

Advisers claimed this was demonstrated when the researchers wanted to send out inappropriate questionnaires to farmers, as one independent agronomist (AL) explained '*The questions would have had the farmers falling off their stools. They were stupid. They didn't appreciate the practical implications*'. Advisers felt this lack of understanding led researchers to make certain erroneous assumptions about farming practices, as revealed in results from the farmer questionnaire undertaken by the Rothamsted researchers (see Chapter 4). They discovered that farmers were growing a much wider range of crops and vegetables than had been assumed and it became apparent that the model could not operate for the full range of circumstances that occurred on different farms, that is, that there were holes in the research data. This was viewed by advisers as limiting its commercial application as they wanted to see a wider range of results over a wider range of circumstances especially for different soil types. A particular weakness of the model was exposed in the researchers' assumption that farmers could estimate amounts of manure applied. It was, in fact, found that farmers often had no idea how much manure they were adding. It was also assumed that farmers used a single manure source, however, in reality many farmers were found to be mixing all their manures in a single heap. This was clearly unexpected as the remark below by one researcher indicates.

We were surprised that a lot of people using organic manure didn't really know how much they were putting on because that is an important input. To think they didn't have any idea of how much they were putting on was quite surprising or even what animal it came from as it was all mixed up. I thought they would be using it more carefully; they are so imprecise (Researcher X).

Farmers also unexpectedly had difficulty predicting yield, which was needed as a model input. This was found to be a subjective decision as it could be interpreted as what the farmer would like the yield to be or what he realistically thinks it will be. One researcher (Y) remarked '*When we went to see farmers that was one of the things they were commenting on, they were unhappy about predicting yield and we were surprised we thought they would have a fair idea*', showing this was another unexpected outcome. Researchers also had not anticipated that farmers would want N recommendations specifically for milling wheat and malting barley and for different cereal varieties nor that 43% of farmers did not use standard SI[56] units which were integral to the FRS.

Comparisons of FRS outputs with advisers' current methods of recommending N

Advisers rely on their own locally derived knowledge to different degrees when recommending N fertiliser applications. Rather than use formal processes or guides, advisers have built up experience and intuitive feelings about recommending N through immersion or being deeply engaged in their work. They describe this '*user knowledge*' in terms of intuition or '*gut feel*' as these comments show:

I use a certain amount of user knowledge and it's difficult to replace that, that's the most valuable thing (Distributor agronomist TB).

Having worked in the fertiliser industry I live and breathe N recommendations intuitively (Independent agronomist SP).

We're living with it all the time. Agronomists do this job the whole time they know what's missing (Independent agronomist SD).

Advisers use this knowledge as a reference point against which to compare outputs from SUNDIAL. They judge them in terms of whether they are '*comfortable*' with the figure, or if '*it's what you would expect it to be*'. Some advisers prefer to rely entirely on this '*gut feel*' and do not value tools or guidelines at all, for example, one agronomist (Q) said '*real world experience is more important than most models yet developed*'. Most advisers and farmers did find that the recommendations were comparable with those they normally used and that the FRS did not come out with any great anomalies, although they commented that these were predictable situations anyway. The FRS was found to fall down, however, in situations outside normality where the advisers needed the most assistance. The importance of recommendations concurring with local field observations was stressed for farmers as well, as one independent agronomist (EB) explained '*If a farmer is using the model for predictive purposes, if he's told he has got a model that calculates growth on his field but can patently see the crop in his field doesn't fit the model he looses faith*'.

[56] System International.

Management recommendations from FRS outputs (or other guidelines like RB209) need to be adjusted to suit the diversity of local conditions and farming styles, because of this the value of models are dismissed by some advisers. They feel that models are inadequate to reveal conditions in the field; one independent agronomist (RW) commented '*I don't think models are accurate enough. It's a great idea but you do everything from the seat and not going out of office and I'm afraid growing crops don't work like that, you always have to tweak for local conditions anyway*'. Generally research outputs, in the form of FRS and other tools, are used only as a starting point by most advisers. Modification of recommendations from research by advisers to suit local circumstances is the norm, and outputs from soil tests, FRS and other tools are constantly queried and changed. Advisers bring together experience and practical and local factors such as timing, soil type and where the crop is in the rotation to modify results from tools to arrive at a recommendation they are comfortable with. This transformative process was described by agronomists as follows:

You have to have something as a guideline and then modify it; there is a lot of that. None of the soil N tests or models give the answer on their own, it's a case of using that as an indicator as to what the trend might be, then using gut instinct and historical knowledge to tweak that and make it into a recommendation. That's a lot of what agronomy is about. It's a case of understanding all the different factors, what's the weather, the crop, the soil? (Distributor agronomist RB).

I calibrate my own intuitive recommendation [with SUNDIAL], play about with different scenarios to see if that is what I would suspect then maybe adjust it. If my own predictions are higher by 50-60% then I think whether I'm wrong or it [SUNDIAL] is. If it's only 20% different then it's OK (Independent agronomist PT).

<u>Difficulties advisers encountered in using SUNDIAL-FRS</u>

One of the main concerns for advisers was that as a tool FRS was not easy to use. They claimed that if it was simple, if they could just log on, perhaps as part of their Farmplan/Farmaid system[57], and if the software was developed so that it was reliable, then advisers and farmers alike would accept it. There were many comments

[57] PC systems used by farmers to assist farm planning

about the model not being particularly farmer friendly, due to the layout and the length of time it took to get a recommendation, as one farmer (W) remarked '*Easy is not a word I would use. The complexity of it was not helpful to be honest*'. It was the software glitches, however, that tainted the model for most advisers and their farmers, who tended to judge it on user-friendless as much as output. This was a criticism particularly from less PC literate or interested advisers and farmers who were not prepared to spend time at their PCs and persevere with the model. The point was also made that whereas researchers are familiar with the model, advisers and farmers used it less frequently and found it quite challenging, as one independent agronomist (LS) observed '*The researcher can use it easily, if you're using it everyday, ever so easy. But if you use it once a month, it's not quite so easy*'. A further fault identified by advisers was the time taken to both learn the model and to run it; to derive answers compared to the familiar systems like RB209; and to fit the recommendations into a practical schedule as these agronomists' comments demonstrate:

It was a problem not only learning but if you did get it working, it took too long to get an answer, by the time it was set up and you got one recommendation, using RB209 you could have been on field 15. It's a question of convenience and time. We've used the MANNER programme which is very useful, but SUNDIAL was never user-friendly (Independent agronomist LS).

If it [FRS] did provide specific field information you'd have to compromise to turn it into a more practical tool. It tended to be impractical in terms of fitting into schedules, for instance if I suggested to my farmers they treat field A on 14 February and field B on 15 February 3 miles away, there is no way they would do it (Independent agronomist LS).

Incorporating farmer and adviser feedback

Advisers were paid and were happy to commit time during the consultation phase; they believed they produced some good ideas about how they could use the model and improve its capacity; they also relayed their farmers' suggestions back to researchers. While many advisers just attended meetings and did not use the model to any great extent, some of the more PC literate ones with the time and the interest persevered and managed detailed and regular feedback. These advisers requested up-dated versions and quite a few are still in touch with researchers every spring. There were areas where advisers, together with farmers, did request changes, however, these were not achieved by the end of the project funding and left the advisers disillusioned with the process. Although there were default figures for weather, advisers complained there was no easy way (unless you were very PC literate) in which to input the farmer's own weather data, a specific input, they argued, which is available on most farms. Another request made by farmers was that the FRS should provide N rates for malting barley and milling wheat. When researchers did not implement these changes advisers/farmers felt that research had not served them well, expectations had been raised but not met. As one independent agronomist remarked:

Inputting farm weather data. It was clearly identified as a need half way through and was always promised as a last add on but it never got there. In the end of day, despite all the promises about what they could do, like predict N for malting barley, and for milling wheat to ensure appropriate quality, it never materialised (Independent agronomist EB).

Poor continuity of the project was highlighted as a key problem. Despite good personal relationships and initial enthusiasm, the advisers' experience of dealing with the research community in the SUNDIAL project was tainted by an inconclusive ending, as project funding finished before the FRS was finalised and developed commercially. Most of the advisers involved had expectations of a useful tool being produced and some had committed a fair amount of time to it but failure of anything to materialise led to cynicism and a view that 'promises' made about model development were not fulfilled. Sustaining a relationship with advisers and farmers after the funding had finished became difficult as research staff moved on and contact and interest was lost. Poor communication towards the end of the project meant that advisers were unaware of the outcome and were left generally uninformed and disillusioned.

I spoke to one or two colleagues and expressed my disgust, and they said the same. In the end we felt guilty about taking money and the whole thing had gone phut. No one seems embarrassed or sacked, nothing happened (Independent agronomist LS).

Yes. I remember meetings and some plots near here in trials to validate, they all disappeared, nothing ever came of those either. They spent all this money developing the system, meetings etc. and then it just fizzled out absolutely. No communication and none with the farmers, a typical Rothamsted type MAFF situation, spend all this money and then do nothing (Independent agronomist L).

Despite this concern, many advisers did applaud the FRS development process and saw its only fault as being incomplete, for which they blamed the nature of finite research contracts rather than the researchers themselves. They commended the consultation process, if not the outcome, as this remark demonstrates:

It worked very well and the farmer input was a good pattern to follow, you could see how the farming input altered the attitude of the research staff. The research interfacing with farmers brought that reality of what it's like on farm. It's good to have that, it needed to be and works extremely well, the research staff were receptive, they listened and didn't dictate, they genuinely wanted to know (Independent agronomist PT).

5.5.2 Researcher perspectives on the development of SUNDIAL-FRS

From the researchers' view point they had a very effective and valid research model derived from years of data collection at Rothamsted enabling them to accurately predict soil N dynamics. They saw a funding opportunity to develop this into an FRS for practical on-farm use and, given the difficulties experienced by advisers and farmers in getting N rates right, for them this filled an obvious need. The researchers interviewed were committed and very keen to apply their research to farming problems[58], their intention was to produce something of value in practice, and consulting the advisers and farmers about their requirements was central to the project. One of the great frustrations for them was the fact that the funding finished

[58] This is clear from the number of articles they published in the farming press (see Appendix A3.3).

before the FRS was completed and that there was no budget for on-farm support. They argue that they want to see what they develop used in practice, as that is ultimately their aim, to do the ground work in science and get the message across to farmers, as a researcher (Y) explained '*I want to see my work applied. We didn't want to just put a model out and leave it like that, we wanted some support and that was problem we haven't got the money for that, it's frustrating*'.

Researchers appreciated the advisers involved in FRS and considered them as very supportive to the development of the FRS. They described them as being enthusiastic about a N recommendation system based on a model, and having a lot of useful ideas to contribute as well as undertaking most of the evaluation. Researchers valued their knowledge and experience concerning N recommendations, as this researcher (X) remarked '*The agronomists have been excellent. They were very knowledgeable; they had been doing it for a number of years and were putting on quite sensible amounts*'. Researchers wanted to recognise the advisers' contribution and included all the names of those involved as authors in an academic paper published about the outcome of the consultation (Smith et al. 1997). They also respected advisers' suggestions about approaching farmers, arranging meetings and changing the style of a questionnaire they had proposed. Advisers, farmers and researchers all saw the benefits of using advisers, for example, farmer (S) said '*They were perfectly right they had the expertise in agronomists and allowed agronomists to invite a number of farmers to be involved; from that perspective I would have thought they were spot on*'.

The researchers also wanted to involve a representative sample of farmers to ensure they were not just getting a false impression of how important farmers would find the FRS. One researcher (Y) explained '*We wanted to get some that would say that's load of rubbish and we did, that's what we were after*'. In terms of whether the data had holes in it, the researchers argued that their intention was to produce a workable model based on a complete range of crops. The researchers were committed to using the consultation to get a broad picture of crops and farmers' interests, as a researcher explained:

The farmer consultation exercise was really to make sure it was providing what they required in an easy and user friendly way. Yes we wanted a wide range of farms, soil types and crops as possible; we didn't just want all winter wheat (Researcher X).

After consultation they devised a running prototype FRS, it was taken out again and they had about five group meetings at different locations where a presentation was made and feedback sought. Researchers found group sessions useful but quite demanding; they valued both adviser and farmer feedback and showed a genuine interest in wanting to learn from the practitioners, overall the mechanism of consultation was commended as very positive, as these comments reveal:

Groups were more useful, with one to one everyone had their say, but on a group basis, you got lively discussions and a lot of good feedback, it was quite challenging being the person going along having these comments flung at you (Researcher Y).

That was the real strength of it. Rather than taking the attitude, 'we are researcher, we know everything', they could go to farmers for information (Independent agronomist EB).

I can't see any other way to do it, using an interface like us that deals with farmers on a daily basis, how else would Rothamsted do it? (Independent agronomist AL).

However, researchers found that some advisers and farmers made 'impractical' suggestions to modify the model, which the researchers were unable to implement because of time, funding, the inappropriate nature of the suggestion and software challenges. For example, some farmers and their advisers wanted the model to deal with different crops and cereal varieties but researchers felt that would be far too complicated and that there was not enough difference to warrant this distinction. As one researcher (Z) said '*Farmers would like us to model everything but we have to stick to the more common crops*'. A number of farmers and their advisers wanted the model to differentiate between wheat grown for milling and barley grown for malting because these products are required to have specific N contents. Researchers saw some of these requests as demonstrating a lack of understanding of the model, as a researcher (X) explained '*It's a model that looks at soil rather than at the crop, this* *created a bit of an impasse*'. Farmers and advisers also wanted them to include other nutrients (P, K and S) as well in the long scheme of things but researchers argued that was not really practical given the time constraints. Despite best intentions the researchers had difficulty in responding to many of the comments, as this researcher's explains:

Some comments we didn't feel we could ever be able to achieve. We certainly got a lot more ideas than we had time to do. I'm still thinking of things to do off it now. Originally we made it completely flexible so you could say optimise the amount and timing and type of recommendation and set the dates and get it to optimise on those dates but the screen was too complicated. They said 'we don't want that it's too complicated' so we took it out. We just made it so you got optimisation of the amount and type but since then people have come back and said 'oh we like the old one better'. It's impossible to please everybody. You have to make you own mind up (Researcher X).

Despite these difficulties, considerable changes were made following the consultation. Recognising that farmers had difficulties in predicting yield, which was an input needed for the FRS, the researchers introduced a crop model into the FRS to predict yields for them (although advisers pointed out that standard yields were used whereas quite a lot of farmers were producing high yield). The layouts were also changed to make it user-friendlier, it was menu driven and certain workings were hidden. The researchers took on board the idea of layering, so that it could be used in a relatively simple way to get recommendations, although it was possible to see the workings behind it if necessary. Researchers accepted that some areas were weak, for example, the inability to easily input farm weather data was being worked on for the next version. Researchers were sympathetic to some comments and intended to make changes including combining FRS with a farm management package so farmers would not have to enter data twice. Also they wanted to accommodate manure mixtures but had not been able to because of time/funding constraints. The key problem in the researchers' view was the termination of the contract funding leaving many areas undeveloped.

5.5.3 SUNDIAL-FRS: summary and discussion

The process of transforming a research tool into a usable FRS for advisers and farmers has been shown to be complex and problematic. These problems were underpinned by researchers, advisers and farmers using different reference points on which to base their solutions and judgements. They all recognise that getting N fertiliser applications correct is a problem but take a different perspective on resolving it. Advisers criticise researchers as being too academic, lacking an understanding of, and making assumptions about, farmer practice, and consequently producing technical/scientific outputs which cannot be assimilated into practice. Researchers meanwhile believed they had a sound research model and that by consulting farmers and advisers about their requirements they could produce a useful FRS. They attributed lack of development and progress to research funding constraints, and overwhelming and sometimes inappropriate feedback.

Advisers and researchers had different understandings and expectations of what an FRS could do and achieve, and each drew on their own norms of knowledge as a reference, researchers looking to the validity of the original SUNDIAL research model, advisers to their own experience. Even when feedback was sought from the practical community, researchers experienced difficulties in handling it because advisers and farmers had not understood what the model could achieve. Advisers saw their own locally derived '*user knowledge*' and '*real world experience*' as irreplaceable and viewed the FRS as only a supplement to this seeing its value only in unfamiliar situations. Parker and Champion (1997) similarly found that most common situations were well understood by farmers and advisers so the Decision Support Systems (DSS) were only used in exceptional circumstances where their experience failed. In this sense advisers in this study behave exactly like farmers who often reject technical interventions preferring to rely on their own experience. Farmers, like these advisers, also resist having their decision-making processes by-passed by technical intervention such as DSS (Carberry et al. 2001) or precision farming (Tsouvalis et al. 2000a). However, Carberry et al. (2001) also found that any scepticism could be overcome if farmers and advisers could compare model performance with their experiences on farm. This 'credibility check' involved advisers and farmers actively engaged in testing different scenarios for actual farms, and allowed them to explore familiar systems in a manner equivalent to learning from experience. Arguably had FRS been able to develop and have a longer period of trialling and use on-farm for such 'credibility checks' the same would have been achieved.

The results also suggest that FRS was in some respects perceived as a threat to the advisers' own integrity and experience. This was also noted by Parker and Sinclair (2001) who suggested that as well as concern about advisers becoming obsolete, farmers were worried because they did not want to substitute their advisers with an impersonal DSS, due to loyalties and the 'psychological support' they offered.

Other research examining the experiences of model-based interventions on farming practice has endeavoured to discover why the use of agricultural DSS by land managers has been low (Parker and Sinclair 2001; Leeuwis 1993a,b; McCown 2001, 2002). These studies also registered gaps between science and practice and in particular identified lack of user involvement in DSS design as hampering its uptake. McCown's (2002) study focused attention on the relationship between the DSS developer and user suggesting that relationships of mutual understanding gave opportunities of creating systems that use comparative advantages of both scientific and practical knowledge. The value of user-centred DSS designs was expounded by Parker and Sinclair (2001) who identified a number of benefits to involving users in the life span of the DSS. In SUNDIAL-FRS the process of consultation was applauded and all parties benefited from the interaction, notably the researchers who demonstrated a willingness to learn and change the model in response to farmers' needs, as one agronomist said '*The research interfacing with farmers brought that reality of what it's like on farm... the research staff were receptive, they listened and didn't dictate, they genuinely wanted to know*'. The inconclusive ending to the project due to finite funding was blamed for leaving many advisers and some farmers disillusioned about the process. Further dialogue and mutual understanding could have been achieved arguably if this AKIS constraint was removed.

5.6 Chapter summary and discussion

The first part of this chapter outlined the patterns of linkage and networks between advisers and researchers and suggests an advisory community actively acquiring knowledge from research about soil management. However, the ineffectiveness of formal linkage mechanisms and advisers differential access to information due to the competitive environment between agribusinesses were highlighted as major constraints to exchanging knowledge about soil in the AKIS. Networking through personal contacts was shown to be increasingly used in a more fragmented AKIS where traditional institutional linkages are failing. This demonstrates that the factors that enable and constrain how advises engage in soil knowledge processes can be found at the macro-level but are resolved at the micro-level (displayed in Figure 5.1)

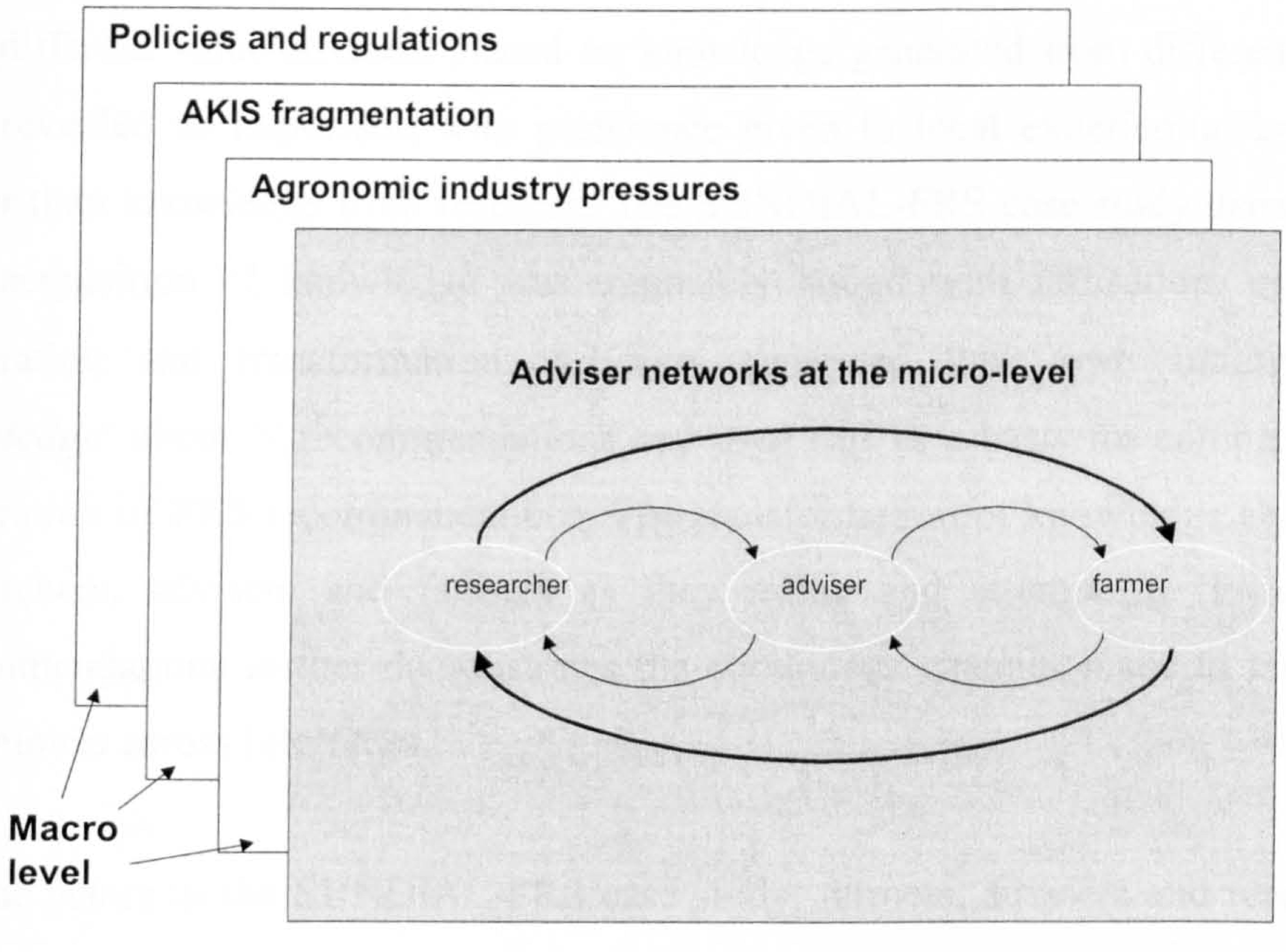


Figure 5.1 Advisers resolving macro-level constraints at the micro-level.

as is consistent with the actor-oriented understanding. The predominant macro influences are the AKIS fragmentation caused by insufficient connections between research and advisers, overarching economic drivers acting on the agronomy industry which further restricts communication and access to information, and policy and regulations. The chapter went on to reveal how the inadequacies of linkage mechanisms were mirrored by a difference in values and perspective between researchers and advisers concerning research outputs. Thus demonstrating that providing links between sub systems in the AKIS does not necessarily guarantee true dialogue and understanding because of what Waldenstrom (2002) describes as social, professional and cultural dis-connectedness and discontinuities. This was demonstrated clearly by the SUNDIAL-FRS, where differences in adviser and researcher understanding of the FRS capabilities, and flawed assumptions about practical farming constraints made by researchers, prevented full understanding between advisers and researchers being achieved. These tensions at the social interface due to discrepancies in norms and values of the groups of advisers and researchers underpin the fragmentation at the institutional interface caused by lack of continuity in research funding. Thus the AKIS constraint of limited research contract funding is reinforced by dissonance at the social interface between these two communities.

The different value advisers placed on knowledge generated from different sources was revealed as important, with preference given to local experiential knowledge rather than knowledge from research. The SUNDIAL-FRS case study demonstrated that acquisition of knowledge was intimately bound with utilisation, generation, integration and transformation. Advisers generated their own intuitive '*user knowledge*' about N recommendations and used this as a basis for comparison and integration of FRS recommendations. The transformation of knowledge about N by researchers, advisers and farmers as they refine and attempt to 'localise' the recommendations further demonstrates the continuous changes made to knowledge as it moves across interfaces.

All the actors in the SUNDIAL-FRS case study, farmers, advisers and researchers, are potentially sources of and users of knowledge about soil management and all participate in its transformation. Thus as Ward and Munton (1992) found for pollution regulation, the knowledge available to all parties is not fixed, its value depends on who produces it and by what means it is transmitted. The results have shown that advisers' relationship with knowledge is complex and the manifold and individual way that advisers use different devices to engage with information and with other actors in the AKIS goes far beyond the simple notion of acquisition, transfer and utilisation of knowledge, which the AKIS suggests. Although the AKIS offers a useful framework in which to situate this study, it can only provide a limited understanding of the dynamic set of processes advisers engage in.

The next chapter investigates adviser-researcher interfaces further but in the context of the advisers' interfaces with farmers in recognition that advisers' practical experiences with farmers can often explain the advisers' different values and perspectives towards research and environmental policy as described in this chapter.

Chapter 6

RESEARCHER-ADVISER-FARMER INTERFACES IN THE CONTEXT OF SOIL BEST MANAGEMENT PRACTICE

6.1 Introduction

This chapter is concerned with soil best management practice knowledge processes across the advisers' interfaces both with the research and with the farming communities. It understands that advisers' interactions with the research and policy communities cannot be considered in isolation but are influenced and explained by their interactions with the farming community.

The chapter is concerned principally with adviser utilisation of soil best management practice and is presented in two main parts. The first part provides empirical evidence from the questionnaire analysis on patterns of advisers' utilisation of soil best management practice guides and tools derived from research (section 6.2) and advisers' concern and awareness of soil degradation (section 6.3). Section 6.4 provides an exploration of the extent to which different types of advisers contribute to soil management decisions on the farm. Section 6.5 provides a summary of this analysis and completes this first part of the chapter.

The second part of the chapter extends the analysis by providing results from the Landcare (section 6.6) and Soil Management Initiative (section 6.7) case studies, which explore advisers' interactions with the research and policy community in the context of the practical decisions they have to make on-farm. Insights from these case studies expands the analysis (in sections 6.2 to 6.4) beyond simple patterns of utilisation to understanding how and why advisers use or do not use soil best management practice knowledge. Each case study section is concluded with a summary and discussion. The chapter concludes with a discussion of the implications of the results presented in the whole chapter.

6.2 Advisers using and recommending best management practice tools and guides for soil

6.2.1 Adviser use of guides that assist best management practice for soil

The extent to which advisers are aware of and use the Soil Code and other DEFRA/ADAS best management practice guides provides an indication of the extent of use of formal sources of knowledge. Questionnaire figures (Table 6.1) suggest that use of the Soil Code is reasonably high, the majority of respondents using it at least sometimes. Figures for individual adviser types (Figure 6.1) demonstrate that DEFRA, ADAS and conservation advisers use the Soil Code the most, whilst distributor agronomists use it the least with 31% never using it. Fewer advisers use the Soil Erosion Manual; the data shows that 58% of all respondents never use it, despite 57% of all respondents having observed severe incidents of soil erosion (as reported later). This may be because this is a less established document than the Soil Code and addresses more specific problems and soils; however, it has been the subject of recent campaigns and seminar training. ADAS and conservation advisers made greatest use of the Soil Erosion Manual (Table 6.2). As a community, surprisingly, conservation advisers claimed to use these documents more than the other advisers.

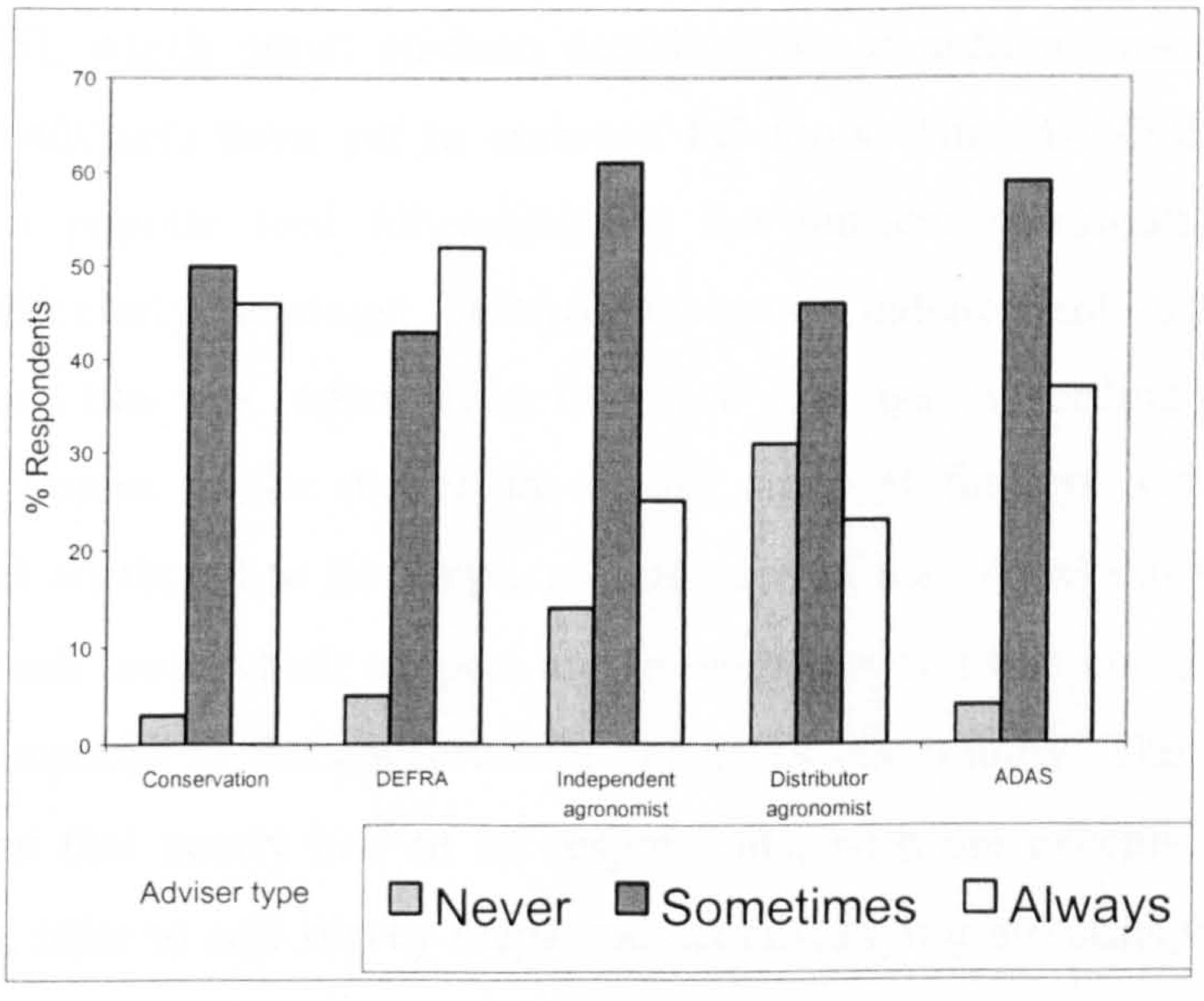


Figure 6.1 Adviser use or recommendation to farmers of the Soil Code.

Table 6.1 Adviser use or recommendation to farmers of DEFRA publications.

	% All respondents		
Publication	Never	Sometimes	Always
Soil Code	11	55	34
Erosion Manual	58	37	5

Table 6.2 Adviser use or recommendation to farmers of the Soil Erosion Manual.

	Adviser type % respondents				
Frequency of use	Conservation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	25	64	75	62	45
Sometimes	72	29	22	23	50
Always	3	7	3	15	5

6.2.2 Adviser use of tools that assist best management practice for soil

The extent of use of tools and soil analysis by advisers is shown in Table 6.3. A very small proportion of advisers use soil analysis but this may be due to expense, which has to be passed onto the farmer, or to lack of advisers' skills and understanding in taking the sample and interpreting the analysis. Limited use of Decision Support Systems (DSS), which assist on-farm decisions about nutrient management, also suggests that advisers have yet to embrace PC tools. The MANNER PC model, however, is a popular tool for estimating the nutrient contributions made by manures, particularly amongst ADAS advisers, independent and distributor agronomists and this was supported by interview findings. According to one ADAS adviser 4000 copies of the model are in use amongst farmers and advisers. Its popularity was attributed to its simplicity and ease of use. Agronomists have more exposure to such tools which support arable decisions and this could explain their higher use compared to the conservation and RDS community. The questionnaire data also show that nearly half of all respondents, with the exception of DEFRA RDS advisers, refer to soil survey maps and accompanying bulletins which provide technical and management data.

Table 6.3 Adviser use of tools when advising farmers.

	Adviser type % respondents				
Tools	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
DSS	9	5	22	30	n/a
Soil analysis	0	0	3	8	9
Soil Survey	56	21	44	54	61
MANNER	12	23	53	46	74

Questionnaire data (Table 6.4) and interviews show that the use of the fertiliser guide RB209 is widespread among all advisers with 95% of all respondents from the arable sector using it at least sometimes. Higher use of the ADAS Managing Livestock Manure booklets among mainly independent agronomists and ADAS advisers suggests that they are integrating nutrients from manure into arable fertiliser schedules (Table 6.5). Not surprisingly there is higher use of RB209 and the booklets by ADAS advisers than other adviser types.

Table 6.4 Adviser use of RB209 when advising farmers.

	Adviser type % respondents				
Frequency of use	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	39	44	7	8	0
Sometimes	57	22	40	38	30
Always	4	34	53	54	70

Table 6.5 Adviser use of ADAS Managing Livestock Manure booklets when advising farmers.

	Adviser type % respondents				
Frequency of use	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Never	18	50	16	46	4
Sometimes	78	33	62	31	65
Always	4	17	22	23	31

6.2.3 Adviser recommendations of best management practice for soil

Relatively wide usage of tools and guides described above suggests that advice based on best management practice principles is being given. Indeed questionnaire results indicate that a large proportion of respondents are already recommending best management practice for soil. Increasingly, advisers appear to be accounting for nutrients in manure (although this is not across the board) with 82% of all respondents stating that they had recommended this in the last two years. Wide distribution and use of MANNER and Managing Livestock Manure booklets would support this high figure. A large proportion of all respondents (77%) also claimed they had recommended targeted N in the last 2 years and more than 70% have recommended carefully timed cultivations, minimum tillage and buffer strips (Table 6.6)[59]. Fewer advisers recommend the more specialist practices such as precision farming and bi-cropping. Figure 6.2 shows that advisers from all sectors recommend these practices to the same extent apart from RDS advisers; commercial and conservation advisers appear to contribute to soil best management practice to the same degree as ADAS advisers.

Table 6.6 Adviser recommendations of best management practices in the last 2 years.

Cultivation recommend-ations	**%**	**Nitrogen recommend-ations**	**%**	**Anti-erosion measures**	**%**	**Others**	**%**
Carefully timed cultivation	82	Targeted N	77	Buffer strips	73	Green manures	42
Minimum tillage	70	Manure N value	82	Contour ploughing	24	Bi-cropping	10
Low compaction machinery	58			Cover crops	52	Precision farming	28
Early autumn sowing	58					Permanent grass	48

[59] Using correlations relationships between the practices listed in the Table 6.6, three categories of recommendations were identified. Significant (at 0.01) correlations (2 tailed Pearson) were found between numbers of respondents recommending the cultivation practices of carefully timed culitvation, low compaction machinery, earlier autumn sowing and minimum tillage; between numbers recommending fertiliser practices of targeted N and N value of manure; and between numbers recommending the anti-erosion measures of buffer strips and contour ploughing. This suggest that advisers might specialise in some common soil best management practice.

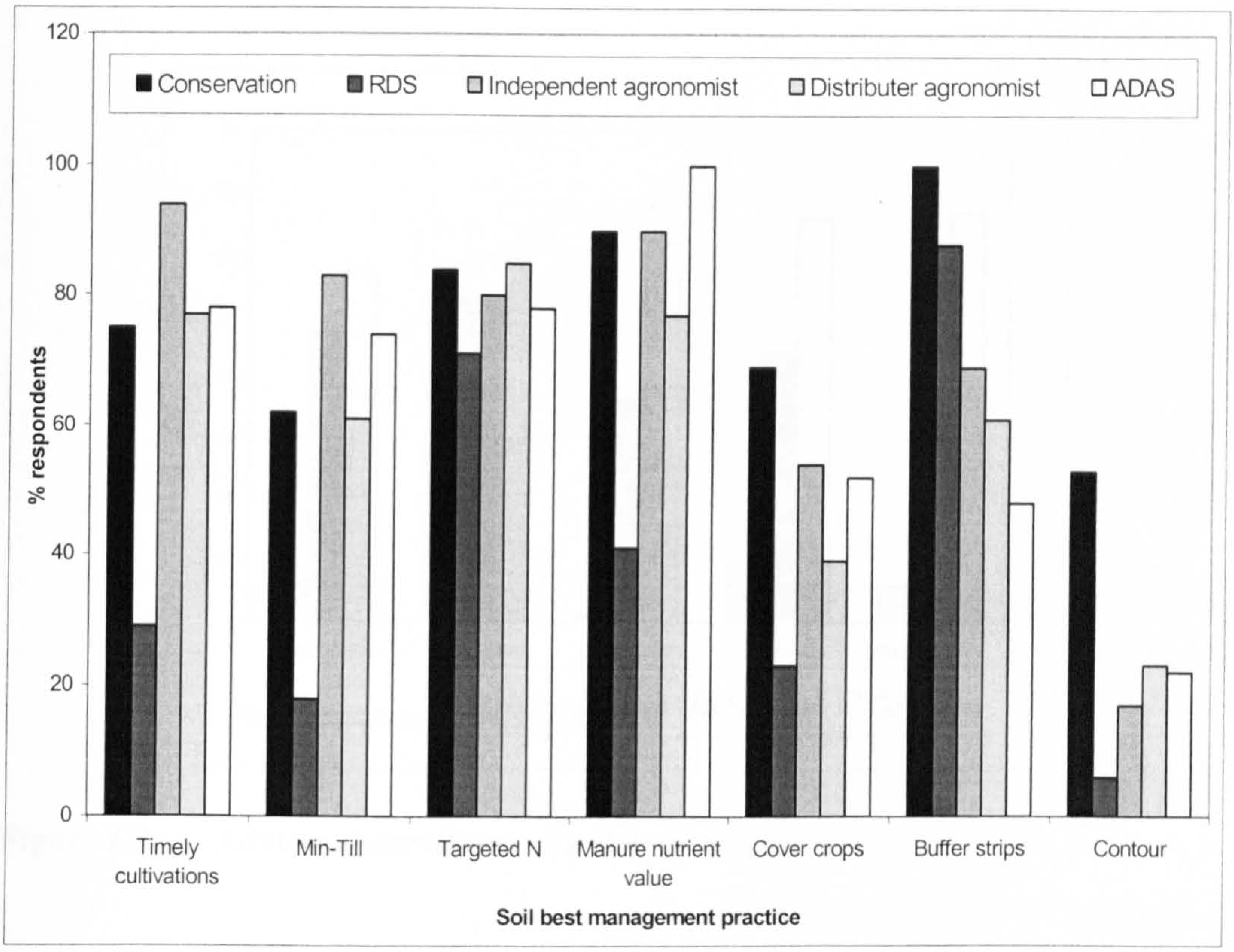


Figure 6.2 Adviser recommendations of soil best management practices in the last 2 years.

6.3 Advisers' observations, concerns and understanding of soil degradation and protection issues

6.3.1 Adviser observations of soil degradation

Observation of local conditions has some impact on how advisers perceive issues of soil degradation and whether they have concerns about it. It is striking that more than 50% of all the questionnaire respondents had observed what they described as 'severe' water erosion, compaction, capping and poor drainage attributed to inappropriate land use over the last 2 years (Figure 6.3). Obviously some soils are more vulnerable to degradation than others and as this data cannot be related to any particular soil type, care must be taken in its interpretation (for example the small percentage witnessing wind erosion is likely to be the result of its restriction to specific soil types in the eastern counties).

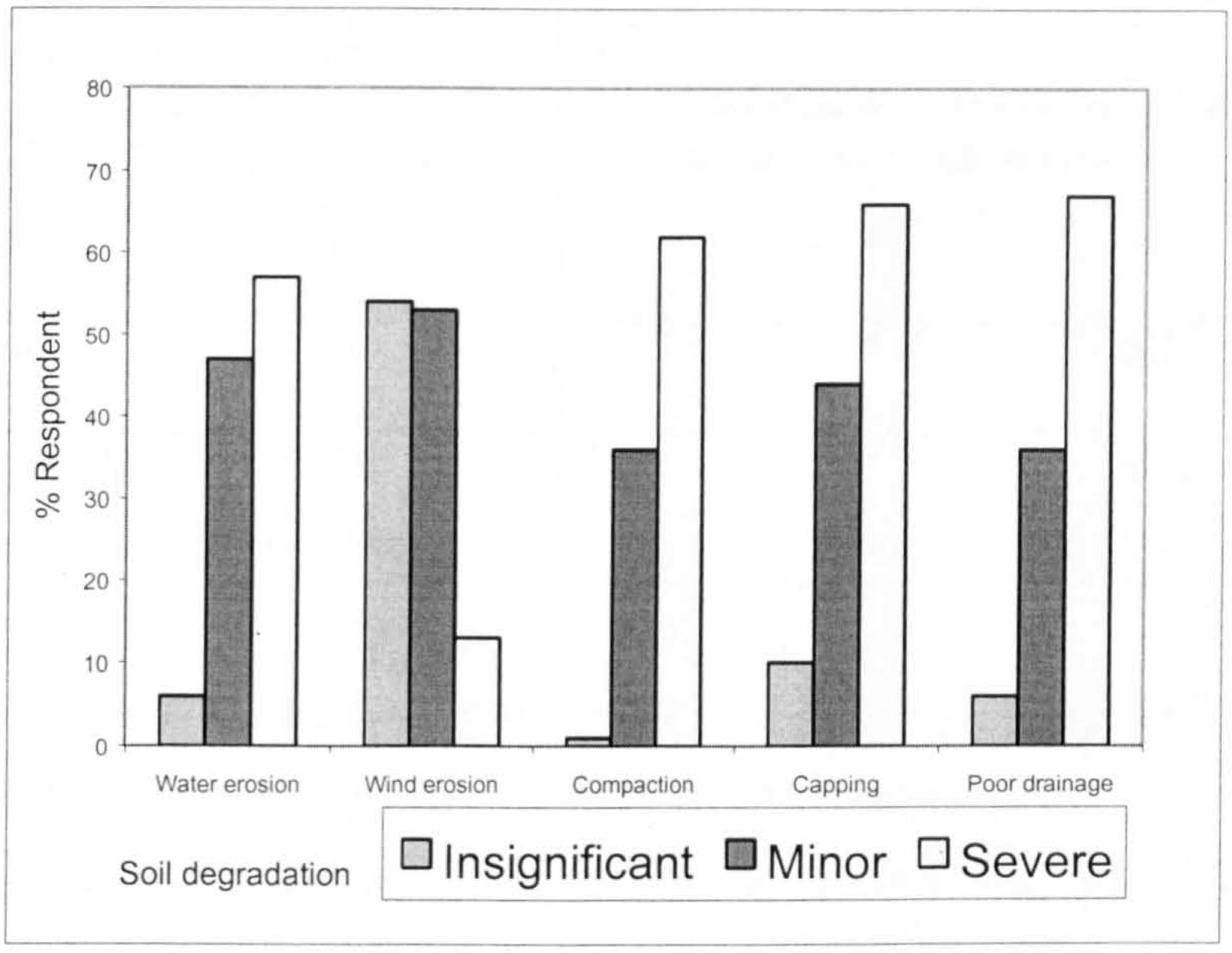


Figure 6.3 Adviser observations of soil degradation.

Nearly all respondents stressed the localised and irregular nature of degradation, and its occurrence being coincident with extreme wet conditions. The questionnaire data do, however, give an impression that many advisers are observing a range of soil conditions which they interpret as symptomatic of degradation.

6.3.2 Adviser concern and interest about soil

In accordance with these observations of soil degradation, more than 65% of all respondents thought that soil degradation was a problem in English agriculture (Table 6.7 and Figure 6.3). Notably fewer independent agronomists (65%) considered this to be problem compared to other advisers, such as RDS (83%) and conservation advisers (100%). Most agronomists[60] noted the localised nature of soil degradation and were reluctant to call it a blanket problem.

[60] The term agronomist is used here synonymously with crop consultant

Table 6.7 Adviser views on the soil degradation problem in English agriculture.

	Adviser type % respondent				
	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
No problem exists	0	0	18	0	4
Don't know	0	17	7	25	26
Yes problem exists	100	83	65	75	70

Advisers' interests in soil protection issues and policy developments were also assessed in the questionnaire by establishing their awareness of two key policy documents, the RCEP Report '*Sustainable Use of Soil*' and the National Soil Strategy (as described in Chapter 2). The responses demonstrate a relatively low awareness overall but significant variability between different advisers types. Distributor agronomists and ADAS advisers are much more aware than other advisers with conservation and RDS advisers being least aware (Table 6.8). Thus those who had most concerns about soil degradation were least aware of policy developments.

Table 6.8 Adviser awareness of soil protection policy developments.

	Adviser type % respondent				
Policy Document	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
Sustainable Use of Soil RCEP	3	5	22	31	30
National Soil Strategy	18	20	27	46	48

6.3.3 Adviser interpretations of 'sustainable soil management'

In an attempt to gauge advisers' understanding and interpretation of soil degradation and protection issues the questionnaire asked what they understood by the term 'sustainable soil management'. The vast majority (93%) of respondents were able to provide a plausible definition and some comments demonstrated an in-depth understanding of current views about soil sustainability. Two main types of interpretation were evident (Table 6.9). The first interpretation, given by 55% of respondents, relates to the generally accepted view about the sustainable use of resources, that soil is a resource which should be managed in the long-term to sustain its functional capabilities. The majority of conservation, RDS and ADAS advisers held this view.

Table 6.9 Definitions that characterise the advisers' main interpretations of Sustainable Soil Management (SSM).

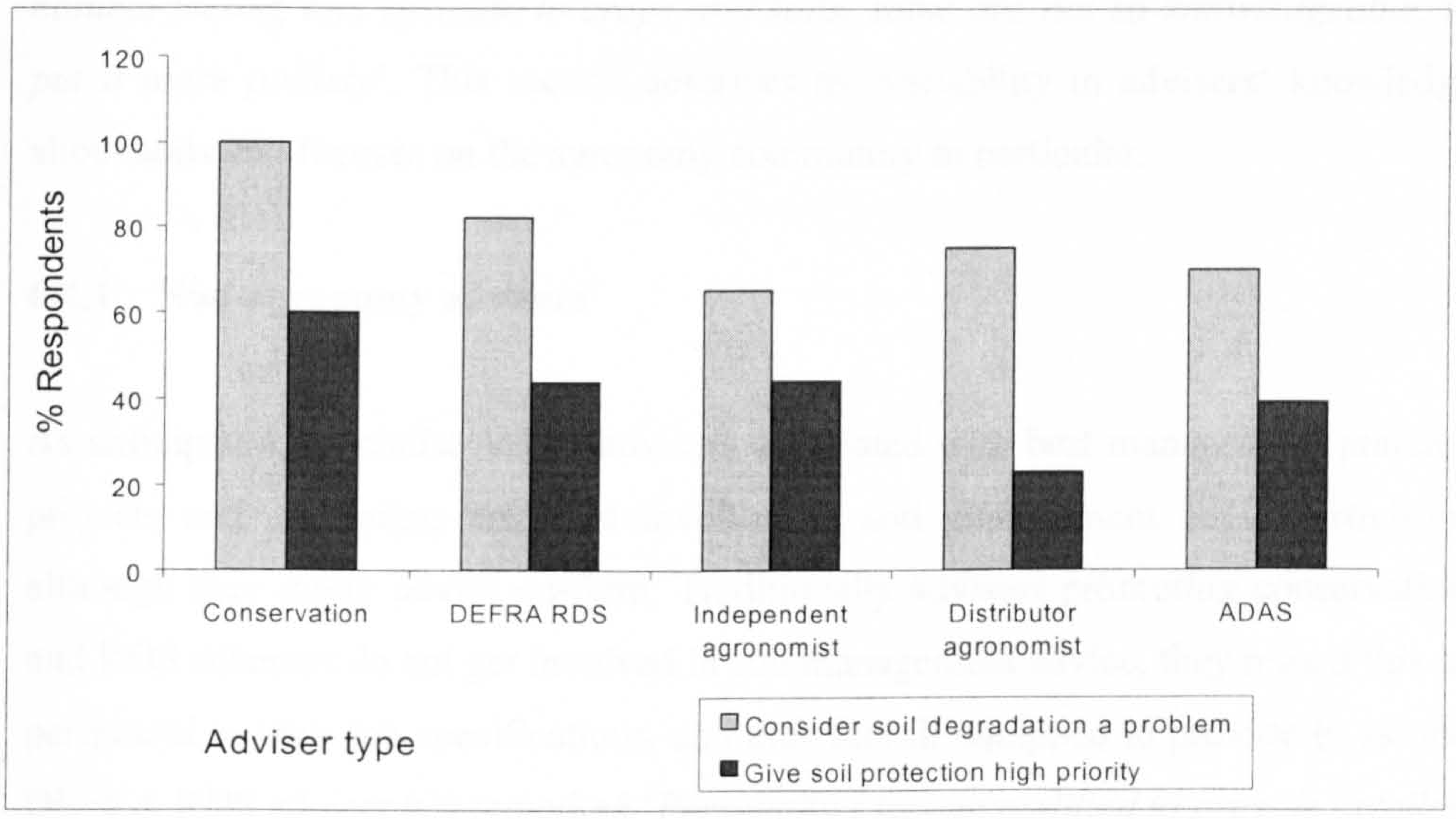
Interpretation of SSM	Typical definition given
Long-term view 55%	*Manage soils in a way that will maintain their long- term ability to perform their vital function.*
Productive function Farmers are already achieving SSM 38%	*Management that keeps the soil in optimum state for production of crops.* *First and foremost the only sustainable farming is profitable farming.* *'Sustainable' is a buzz word. The land on which I advise has had crops on it for many hundreds of years.* *We are growing larger crops today than at any time before with soil structure better than at any time in the last 20 years. That's sustainable management!*

In the second interpretation, 38% of respondents viewed 'sustainable soil management' in terms of the soil's productive and economic function. Not surprisingly, this view was held mostly by agronomists. Some within this group considered 'sustainable soil management' as being already achieved by farmers and others, with more extreme views, dismissed 'sustainable soil management' as jargon or described it as a term which has been 'hijacked' by environmentalists to maintain their 'moral high ground'. A minority argued that 'sustainable soil management' depended entirely on purpose, recognising that soils provided different functions under environmental and agricultural objectives.

6.3.4 Priority given to soil protection by advisers

Whether the awareness and concerns about soil degradation expressed by advisers translate into practical recommendations needs to be considered. The questionnaire data show that the majority of all adviser types do not give high priority to soil protection in their current jobs, with distributor agronomists giving this the least priority and conservation advisers claiming to give it the highest priority.

Figure 6.4 Adviser perception of soil degradation compared to priority given to soil protection.



Most interesting is the discrepancy between the advisers that recognise soil degradation as a problem and those who accord soil protection high priority, the biggest difference being in the distributor agronomists' category (Figure 6.4). These figures suggest that although they might recognise degradation as a problem, advisers, particularly distributor agronomists, are constrained in reacting to it.

The results from sections 6.2 and 6.3 demonstrate that advisers from different sectors are concerned about soil and give priority to soil protection to different extents. These differences are explored in more detail in the following section.

6.4 The extent to which different types of farm advisers are concerned with soil and involved in soil management decisions

As the previous section indicated advisers' concerns about soil, their use of relevant tools and their recommendation of soil best management practice range widely. This section explores this variability in more detail revealing that advisers differ in expertise, background and nature of employment and have a range of views and perspectives forged from their own unique set of experiences. There is a great range of capability, or as one Environment Agency (A) representative commented '*There is a spectrum of the very good and the uninformed*'. One farmer (AF) acknowledges this range of ability saying '*Some advisers are very knowledgeable, they have a natural feeling and aptitude to crops and soils, some are not so knowledgeable, to put it more politely*'. This section describes the variability in advisers' knowledge about soils and focuses on the agronomy community in particular.

6.4.1 Non-agronomy advisers

As anticipated, specialist ADAS advisers associated with best management practice projects and campaigns are most involved in soil management advice provision although they rarely advise on-farm. Traditionally advisers promoting conservation and RDS schemes do not get involved in soil management advice, they regard this as peripheral to their job specifications, and they feel ill equipped to provide it, as one DEFRA RDS adviser (Q) remarked '*Personally I feel unqualified to provide detailed soil management advice. Most FWAG, RDS and other advisers I believe are in the same position*'. Some non-agronomy advisers, however, are more versed in some aspects of arable practice as they may have started their careers as agronomists or arable advisers, notably the RDS advisers who have been drawn from FRCA (formerly ADAS) and some FWAG advisers who started their careers as independent agronomists. In addition conservation advisers are becoming increasingly aware of the importance of soil best management practice to conservation matters such as polluted habitats. Some FWAG advisers are providing pollution prevention advice and undertaking farm nutrient budgets for farmers in problem river catchments funded by the Environment Agency and English Nature. Use of the Soil Code, RB290, soil survey bulletins and maps and Managing Livestock Manure booklets amongst FWAG advisers shows greater involvement in farm fertiliser decisions, although only 12% respondents were FACTS registered.

6.4.2 Agronomists

As a community the agronomists have greater experience with soil than the conservation advisers both in terms of number of years spent being an adviser (Table 6.10) but also in the nature of the work, which involves regular crop walking and interaction with farmers. Farmers are appreciative of the breadth and range of knowledge agronomists accrue while advisers themselves put great store in this, particularly with regard to soil, for example, one independent agronomist (Questionnaire respondent) remarked '*40 years of personal experience of handling soils is invaluable*'.

Table 6.10 Length of experience as an agricultural adviser.

	Adviser type % respondents				
Years working	Conserv-ation	DEFRA RDS	Independent agronomists	Distributor agronomists	ADAS
<10 years	84	56	10	16	32
10 –19 years	16	26	64	77	36
> 20 years	0	18	26	7	32

Determining how agronomists typically affect soil management decisions is difficult to establish as they are associated with a range of advice, consequently defining an agronomist is almost impossible as this statement reveals:

Agronomists? There's no such thing as a standard agronomist. Everyone and his dog calls himself an agronomist now. It's a term that covers a multitude of sins. Most would be so called crop consultants who do pesticides because that's the starting point. There isn't a standard adviser, some are PhD boffins who take your sample away, look at it under microscope and identify a weird sub-strain of some bizarre disease and then tell you there is nothing you can do about it and others will say 'I'll help you read the can' (Independent agronomist DG).

Those supplying whole farm agronomy advice by very virtue of the fact that they advise on cropping and rotation plans, seed rates and varieties, nutrition and to some extent cultivation *are* advising on soil management issues, although they do not distinguish soil management advice as a separate factor. All the agronomists interviewed emphasised their professional integrity and quality of advice and stressed the need for whole farm agronomy as opposed to just one component of it. There is some professional rivalry between independent and distributor agronomists. The former tend to dismiss distributor agronomists as providing advice limited to crop protection and being the pawns of the pesticide industry. The distributor agronomists, however, particularly from the larger distributors, regard themselves as providing comprehensive agronomic advice of better quality than smaller organisations or indeed the independents and were keen to distinguish themselves from the chemical representatives who are perceived as just '*flogging*' chemicals. The two statements below demonstrate these competing views:

Trade advice is specific to a crop already planted by farmers and then is given on a field by field basis. We work more closely than distributors, for example, I will advise on what to plant, the rotation, the variety and the blocks to be dealt with as one unit. It's structural advice and then agronomy field by field, we work as a partnership (Independent agronomist N).

Between UPA and Masstock you've probably got the cream of adviser industry. Without being too derogatory to our competitors, we have a strong environment side while some of the smaller agronomists would just be purely crop protection and ignore all around advisory capability (Distributor agronomist GB).

The bigger distributor firms (for example Agrovista, UPA and Masstock) claim not only to keep their own agronomists informed about environmental and/or best management practice developments, but also employ their own environmental specialists in response to client and policy demands. They ensure their own staff are trained and up to date, for example, 100% distributor agronomists who responded to the questionnaire were FACTS registered. However, despite these claims distributor agronomists responding to the questionnaire used the Soil Code the least and gave soil protection the least priority.

Most agronomists interviewed regard soil best management practice as sound practice, and believe they are already promoting it as part of their day-to-day advice. However, it is clear that they regard soil management from a farming perspective rather than a soil/environmental protection one. Soil is not singled out as a resource that needs particular attention but its management is seen as integral to the whole farming system, as such it is not accorded any higher priority than any other agronomic factor. Many agronomists, however, are increasingly recognising the dual benefits to the environment and the farm business of best management practice and emphasised the importance of soil as the basic material for farming. Some regard soil protection almost as a personal campaign and pride themselves on being committed to good soil management and up to date on many issues, as the following quotes show:

If you're an agronomist the first thing you should be doing is looking at the soil picking it up and feeling it (Distributor agronomist TB).

I would advise on nutrient crop off-take and soil needs anyway, one matched to the other. What we're coming across now is not particularly new, it's just becoming more formalised (Distributor agronomist RB).

It all goes down to what you're growing on, if you let the top soil drain out of the field you are loosing your growing medium which is silly (Independent agronomist RP).

I've banged the gong for many years that your organic manures are incredibly valuable, use them sensibly. I give them a lot of guidelines and a lot of advice on how to use them. I personally am up to speed with that one (Independent agronomist JC).

I've kept on about seed beds and soil wash. Oh yes, I would haul them over the coals and say 'for Christ sake, look it's ridiculous; you're loosing half your field, apart from polluting the river, the neighbours don't like it, mud into cattle grids and into front gardens'. So yes, but by the time I've got that message across somebody else has been along. I'm not happy for it, it looks terrible, it's ridiculous and I will give them some advice. I don't usually loose customers by being rude to them, although I'm quite rude (Independent agronomist JC).

Other agronomists consider they have a role in raising awareness about soil issues both among farmers and colleagues, even though this is not a particular aspect of their job. One agronomist from a seed merchants, for instance, who had visited the Landcare demonstration farm included information about it in a newsletter to 400 of his clients and personally sent off for the ADAS Managing Livestock Manure booklets for all his work colleagues. Similarly some consultants consider that they have a duty to meet more than just the terms of the contract, and regard themselves as very disciplined. For example, one large consultancy firm undertaking a Farm Waste Management Plan contract for the Environment Agency used the opportunity to try to persuade farmers to utilise FYM and slurry and balance their inorganic fertiliser against it. Another consultant's remark (Questionnaire respondent) '*Our consultancy group has always promoted the truly good handling of soil as a fundamental part of successful cropping*', shows that this was not an isolated case.

Although there are a number of committed and well-informed agronomists, there are also many who are only concerned with crop protection and who will have a minimal input into any other farm decisions. Many from outside the agronomy industry still view all agronomists as being in this category, seeing their advice as limited to crops and as not giving much attention to soils, as one farmer (TG) said '*How we arrived at the crop is less of a concern to him than where the crop is now*'. Some interviewees pointed out that it is the farmers' decisions about the crop variety and the cultivation system that can have more impact than anything the agronomist does, suggesting that agronomists have a minimal input into the important whole farm (and therefore soil) decisions; one independent agronomist pointed out:

If the farmers get their cultivations wrong and their variety wrong for their farm, that has a much greater effect than anything else. The two decisions that are out of my hands are the ones that are going to have the most effect (Independent agronomist LS).

Other farmers agreed with this view saying that soil management issues were of no concern to agronomists simply because they do not get involved in any of those decisions. Indeed some agronomists do tend to see soil management more as the farmers' domain, or that of agronomists with a soils specialism (they estimate this might be only 5% of agronomists). Such agronomists are thought to be only interested in the crop:

They [agronomists] are very good but most take little interest in soils. They expect the farmer to look after the soil and cultivations and they look after the plant and hope it has got some roots (ADAS adviser B).

I suspect a lot advisers in the arable sector are not really giving soil protection advice at all, if they do it's in a situation where the farmer has developed enthusiasm (ESA Project Officer A).

Some interviewees argued that there is a declining population of quality advisers giving comprehensive advice, that there is not much fresh blood coming in to the sector and that the average age of quality advisers is increasing, as verified by questionnaire data (Table 6.10). Within the community of agronomists who are more committed to whole farm advice there are concerns that other agronomists are limiting themselves to agrochemical supplies, as a distributor agronomist (TB) said '*There are plenty of people flogging stuff but not actually giving good sound all round advice*'.

This section suggests that agronomists' involvement in soil management ranges from no input or interest whatsoever to considerable involvement and commitment. This reflects the divergence in questionnaire responses regarding concerns about, observations and recommendations, of soil best management practice.

6.5 Advisers' contribution to soil best management practice: summary and discussion

ADAS advisers involved in environmental and soil protection campaigns are clearly the most qualified and competent as soil specialists, although they rarely advise on a one to one basis on farm. Although RDS and conservation advisers' central concern remains the protection of habitat and wildlife, they are taking a wider interest in arable issues and are increasingly involved in some aspects of soil best management practice through FACTS training and some project catchment work. Indeed these adviser types claimed to use the Soil Code more often than arable advisers and to have the greatest concerns about soil degradation. Winter et al. (2001) reported a similar shift in FWAG's role towards advice on fertiliser rates and pollution prevention. However, for many conservation and RDS advisers, soil management remains of peripheral interest. Agronomists have a range of competencies in soil, whilst many are just concerned with crop protection, there is a cohort who is managing soil as part of the whole-farm agronomy and they are competent, committed and well informed. These results mirror to some degree those of Marshall's (2002) survey which found that some agronomists' environmental skills were well advanced and that they were already giving sound environmental advice, including fertiliser and FYM use, and ICM, often unprompted.

The results show that advisers as a community observe a significant range of soil degradation symptoms which they perceive as severe and the majority are concerned about soil degradation in English agriculture. However, these levels are disproportionate to the relatively low priority given to soil protection, suggesting either that soil management is integral to other advice or there are other imperatives influencing advisers' decisions. Interpretations of sustainable soil management suggest that many agronomists are still committed to what Wilson (2001) calls productivist modes of thinking or what Juntti and Potter (2002) refer to as an 'agrarian agenda', as statements like '*First and foremost the only sustainable farming is profitable farming*' demonstrate. This productivist rather than protectionist perspective may be dictating advisers' priorities in soil protection. This accords with previous commentators' views that regard the advisers' productivist intentions as constraining any progress towards sustainable agriculture (Curry 1997).

In terms of using appropriate soil management tools and guides and recommending soil best management practice, questionnaire respondents claim to do this to a large extent. Use of the Soil Code was not insignificant with 43-61% advisers using it at least sometimes, whilst use of more specialist tools such as RB209 and MANNER is well established in the arable advisory communities. There is evidence of advisers using best management practice knowledge with more than 70% recommending carefully timed cultivations, minimum tillage, buffer strips, using nutrient value of manures and targeting N. High levels of registration with FACTS would also suggest a commitment to improving their soil best management practice skills, understanding and knowledge.

The previous section established patterns of linkages and sources of information advisers use within the AKIS. This section provides further insights in patterns of utilisation of soil best management practice by advisers. It describes a range of concerns about, and competences in dealing with, soil and the variable contribution the adviser community make to soil management decisions on-farm. Chapter 2 suggested that the diverse adviser community operating within a complex AKIS in England has a range of environmental skills and objectives. These results, which provide new evidence about advisers' fitness for purpose with regard to soil, confirm that this is also the case for advisers' knowledge about soil management.

However, as the following case study analysis demonstrates, the relatively high levels of concern, usage of tools and recommendations indicated in the questionnaire results require some qualification. The difficulties these soil best management practices present, both in terms of practical and economic constraints and in terms of adviser and farmer competence are discussed in the following sections of this chapter. These reveal that rather than utilisation of knowledge about soil best management practice being a discrete process, it is intimately bound up with transformation, adaptation and integration, knowledge processes central to the actor-oriented AKIS approach described in Chapter 3.

6.6 Adviser response to best management practice messages: Landcare

This section presents an analysis of the Landcare case study. It provides an in depth examination of the factors that influence the advisers' utilisation of soil best management practice promoted in this project and explores the complex knowledge processes operating across the interfaces between advisers and the research and policy community in the context of practical decisions on the farm.

6.6.1 Advisers' observations of soil wash

The Landcare catchment has been identified as an area where soil wash from agricultural land is leading to diffuse pollution with sediments, nitrates and phosphates causing water quality problems, as described in Chapter 4. There is a range of views amongst advisers working in the catchment as to the occurrence and the causes of soil wash. These mirror the results collected in the questionnaire data presented earlier. Whilst in general terms advisers accept that soil wash can be a problem, there is disagreement as to the extent. Those who have the strongest concerns have witnessed regular incidents of soil wash. Advisers and researchers who belong to the Landcare partnership are in no doubt about the causes of river turbidity which they attribute to large amounts of sheet flow coming off fields running into streams and ditches, for example, one adviser/researcher (G) within the partnership observed '*You only have to look at the colour of the river to see it happening*'. Advisers not associated with the partnership, but working in the catchment, also have concerns; their views are shaped by their own observations in their particular working area. Advisers working in higher risk areas of the Greensand and clay soils, in the Pewsey vale, or with maize farmers in particular recognise a problem, as demonstrated by these agronomists' below:

I think everyone's very conscious about erosion, it's very noticeable on roads. It's a big thing particularly on the Greensand. Some of the gullies in Hampshire are a foot wide and a foot deep, they all got ploughed in and with more rain it got washed out again, unbelievable, quite extraordinary (Distributor agronomist RB).

A tremendous amount comes off the Greensand, I know a farm, I don't advise there someone else does, but the water just runs off with gay abandon. I don't know how aware the farmer is about the condition he leaves it when the crop goes in. I think you just get these flash floods; it comes off no matter what (Distributor agronomist TB).

In contrast, those advisers working with farmers in the less vulnerable chalk soil areas or where there is no maize or minimal slopes rarely observe soil wash. Although they do accept that it can occur in other areas, they stress it is a very localised problem only significant on vulnerable soils, tracks, in extreme weather and where root crops and maize are grown. The comment below is typical of this view.

From my experience driving around South Wiltshire not very much is washed straight out of the field onto the road, there are not huge amounts of soil moving down the road, but there is a fair amount that comes down tracks (Distributor agronomist GB).

As the majority of soils in the catchment are chalk, most advisers interviewed share the opinion that farm management is good with limited symptoms of poor soil husbandry, although they do accept that under certain weather conditions even the chalk soils erode under poor practice, such as excessive cultivation.

You would see last year the chalk doesn't normally run but last year it did, there was classic over working, ploughing then power harrow, drilling it then with showers or heavy rain there is wash after it (Distributor agronomist RW).

Some advisers suggest that it's not always easy to find examples of graphic severe erosion like gullies, more often there are quite subtle signs, small amounts of gullying on tramlines or corners poached by livestock. Spectacular events do occur but are only occasional. It's felt that lack of visual evidence may account for lack of awareness among some advisers and farmers.

Associated with soil wash is the compaction and leaching that can result from manure applications. Large amounts of manure applied to maize are described as exacerbating the problem and leading to nutrient loss, pollution and compaction. Maize is described as a 'convenient situation' and is heavily targeted for manure because of its bare stubble from the autumn right through to the end of April, when all other land has been sown, as a distributor agronomist (TB) notes '*Maize is really the biggest culprit certainly on grassland areas. Even around me you can see fields used every year for the same crop, dumping manure on it, growing maize and leaving it bare in winter*'.

6.6.2 Advisers' contribution to Landcare soil best management practices

Landcare's aim is to reduce diffuse pollution by promoting best management practices for soil including nutrient budgeting through targeted fertiliser application, using the nutrient value of manures and timely and appropriate cultivations (as detailed in Chapter 4). By using such practices it is believed a clear benefit can be demonstrated both for the environment and for the farmer in terms of cost savings, which Landcare describes as a 'win-win' situation. Some advisers, however, argue that such recommendations derived from research outputs do not take not into consideration other factors affecting farm practice and highlight a lack of researcher understanding of the constraints under which farmers operate. In particular they argue that there is a lack of scientific understanding and knowledge on-farm to support the more knowledge intensive practices demanded by the project. These views, which are explored below, demonstrate that advisers' utilisation of knowledge about soil best management practice is not a neutral activity and as such questionnaire responses alone are insufficient to understand and explain the utilisation process.

Measures for preventing soil wash: advisers' contribution

Wash of soil sediments into waterways is a major source of diffuse pollution in the Landcare catchment. Soil wash can result when the soil surface is left exposed and when the soil structure deteriorates following cultivation undertaken in the wrong soil moisture conditions. Decisions about cultivations are seen as some of the most important on the farm but this is an area where advisers are least involved and have minimum confidence and experience. Agronomists in particular acknowledge these limitations, they accept that farmers have the hands-on practical skills and recognise that there are borders they do not cross and talk of the risk of transgressing these.

I'm an advisory agronomist who has a lot of technical information at my finger tips but I'm not a practical farming manager and we are stepping over the borders here a little bit. Most farmers are experts in machinery or like to think they are, so for me to step over...they will listen to me but what they say when I've gone, I don't know. I think a practising farm manager or practising foreman can talk to farmers about practice or setting a machine or going across the hill and will come over with more *credence than an agronomist like me. It's 20 years since I sat on a tractor, machinery has changed and I'm not the most experienced tractor driver anymore* (Independent agronomist JC).

Agronomists also realise that a lot of cultivation decisions are very much '*on the day*' in response to weather, soil and crop conditions and this is often when advisers are not present. As this comment shows the adviser's role is marginal as cultivation is ultimately the farmers' responsibility, whatever the adviser recommends.

Advisers are only as good as the farmer doing the cultivation, all they are doing is advising on what should be done on the farm. They are telling the farmer what to do but it's the farmer that carries out the cultivations (Farmer AF).

Many see the fact that a lot of agronomists are not providing very much advice about cultivations as a weak link, and the absence of hands-on experience of cultivation is held up as a big gap in their knowledge. The emphasis on needing to be a practitioner to understand soil cultivations to engage the farmer on these issues is echoed in many interviews, and is illustrated by the following comment:

A lot of people I know who work in the soils field and agronomy advisory field are actually very weak on soils, on hands-on soils, they really are. They just haven't got their minds around it. One of the fundamental things is timeliness and soil moisture. The only way you'll understand about soil capability and timeliness is by doing it and doing it for quite a while and that's the problem, these people, they don't actually do it (Environment Agency representative B).

Because of their inexperience advisers realise they have to be sensitive in areas where their competence might be questioned, as this agronomist observes:

I am very careful how I put the advice I might bang the gong and say you must do this but when it comes to 'you must set your machine this way' or 'you should consider this machinery' they do listen but I have to be more circumspect in how I put the information across. One has to be very careful when talking about cultivation to farmers, that is sacrosanct, if you start querying or questioning his ability to *cultivate his land you are on very dangerous ground, we discuss it but have to be careful, some farmers know their land and how to cultivate it* (Independent agronomist JC).

These comments suggest that we should reinterpret the questionnaire data which showed that 82% and 58% respondents respectively claimed to have recommended carefully timed cultivation and low compaction machinery in the last 2 years since advisers appear to have limited confidence in advising these practices. Advisers in Landcare, however, did demonstrate an appreciation of the beneficial results of good cultivation practice. Some described how they have observed and felt the benefits of different culitvations to soil structure on farmers' fields through walking over them. They appreciate the sensual feel of soil in the same way that farmers do, the sponginess, firmness, and the usual visual indicators of structure. Referring to Landcare demo plots which compared cultivations, advisers explained how convincing it was to see and feel the benefits:

To actually physically walk on the field and see the difference it made a big impression on me and I wouldn't have got that from a slide, to actually walk on that soil and feel it and see how spongy it was (Environment Agency EPO W).

It's quite phenomenal, the benefits in terms of firmness, the lack of Mn deficiency because the roots are in nice and firm, the lack of erosion compared to the next door neighbour where you see the rivulets going down the field. The point is it's remarkable, even with this much rain we've had. It's remarkable, the different effects the cultivation has made in terms of the soils ability to hold the water (Independent agronomist RB).

These comments suggest that although less effective in advising about cultivations, advisers rely on observations and others senses to build up a repertoire of local knowledge about the benefits of different cultivation practices to soil structure.

As well as having limited experience and competence in cultivations, advisers can actually encourage cultivation that degrades the soil. Pressure on farmers from advisers to undertake cultivations under the wrong soil moisture conditions can increase the risk of soil wash. Advisers are blamed for compelling farmers to undertake untimely cultivations; there is a rush to meet schedules and get crops cultivated irrespective of whether the soil conditions are suitable. This was particularly the case for maize farmers in the Landcare catchment, as these remarks demonstrate:

I've seen it time and time again; agronomists talk about, for example, putting maize in the ground... 'maize should be in the ground by now, everyone else has done it'. Whether the soils are capable or not, it's the pressure (Environment Agency representative B).

For maize growers, there's a very short time and it's very much a pressure job, we're all screaming at them 'you must have maize in by 10 May' and very often they can't get out on the ground until 1 May (Distributor agronomist RB).

Another situation where advice can exacerbate soil wash concerns seedbed preparation. Many agronomists are very keen to have the best fine seedbed possible, which promotes quick crop establishment whereas coarse seedbeds are recommended to prevent erosion. A similar issue occurs with winter wheat, where the appropriate thing to do from the point of view of preventing erosion is to sow early to keep the ground covered, however, this means the farmer is spending a lot more on weed, disease and pest control, and using more pesticides. An ESA Project Officer working in the Landcare catchment explains the problem:

From the point of view of getting crops established quickly, particularly if it's a bit dry and getting residual herbicides to work well, you're looking for fine seed beds but for best practice in terms of erosion you need something coarser, but agronomically, there's a down side as residual herbs won't work very effectively on that, and having sown the crop, if it turns dry it won't come up if it's too coarse. There are all sorts of issues like those which conflict in terms of best practice for soil erosion against best practice for achieving max gross margin on the crop you're putting in (ESA Project Officer A).

Such conflicts that agronomists face between soil best management practice and profitable cropping are explored in more detail in Chapter 7. However, while some might still favour fine seed beds, others realise that to produce them requires more time, diesel and exposes soils to erosion risk, they argue that the farmers are losing out and then the agronomist loses too, as this more enlightened agronomist explains:

A fine seedbed isn't ideal from an economic situation either. The worst thing to do from an environmental point of view and from an economic point of view is to have a field that's eroding or water logged (Distributor agronomist TB).

Nitrogen fertiliser targeting to reduce leaching: advisers' contribution

There has been extensive research to provide the basis for targeted N recommendations, which meet crop requirements. Outputs from this research (listed in Table 2.1) are promoted in Landcare with the aim of both reducing nitrate leaching and saving farmers money. However, in practice, advisers argue, refining fertiliser rates to meet crop demands can be complicated, time consuming and can fail to provide any cost savings. Despite figures showing frequent use of tools when recommending fertilisers (see Chapter 5), advisers in the Landcare project (and elsewhere) stress that achieving the required soil and crop nutrition is a complex process for which they are often ill equipped. As one independent agronomist (N) noted '*In terms of how do I know whether I've got the N rate right? I don't...I'll have a stab at it*'. The difficulties of recommending N and the transformations that occur when advisers sit down to calculate the requirements are highlighted by many advisers, this comment being typical:

After trying many different systems for N recommendations I am right back where I started. I sit down with note pad and I write any number, say 200kg. I think 'well it's going well' so I change it to 160kg, but then again it's a very high yield potential site and we used a lot of fungicide so the figure goes up but then I did put a bit of chicken muck on so maybe it should be 100kg. That's what you do, you bounce about. RB209 is a great starting point and essential stuff, that's where I get my first figure from the indices, then I start playing around with it (Independent agronomist DG).

These comments suggest that although advisers are becoming FACTS registered and using tools to recommend the appropriate practices to reduce fertiliser N use, they are not always confident with the outcome. Whether this is a reflection of their scientific understanding or of the limitations of the tools themselves needs further exploration.

Practical constraints to using targeted N were also stressed by advisers who criticised the researchers as not appreciating the day-to-day farmer practices and schedules. The principle of targeting fertilisers is to use different amounts on different fields or parts of fields to meet crops needs, but this is sometimes not feasible; one agronomist explains:

Yes it's always a problem, not just with fertiliser it's with any input, there is a limit to how detailed you can be, people will not tolerate it. With very complicated spraying, if you have 30 fields of wheat and they are all the same, bar two and those two have problems it may be impractical to treat them differently, you might have to go straight through (Independent agronomist RP).

Others explained that labour availability can restrict adoption of measures to target fertiliser. For instance a farmer will make a blanket application because he only has to pay one man rather than two, or he has another enterprise into which he can divert that man. Some advisers argued that targeting fertiliser is time and hassle, there's also scope for mistakes as you have to rely on the man who is doing the spreading to get it right if he has to change the calibration two or three times a day, not to mention the downtime while the machine is recalibrated. Targeting often means the farmer has to order more grades of fertiliser, and larger farms could end up with four or five grades of fertiliser (straight, blend and so on) to get a fairly precise match to nutrient requirements and they would get charged a lot of money. An adviser operating in the Landcare catchment explains the problem and demonstrates his sympathies towards the farmer.

Any cost advantage of reducing fertiliser input is lost. If you order four tonnes of triple superphosphate you'll get stung on price and it's difficult to deliver it, suppliers don't want to know. From the farmers' point of view getting that precision *is actually difficult for all sorts of reasons and you can understand why they don't want to do it* (ESA Project Officer A).

Failure of researchers to appreciate the financial implications of using targeted fertiliser was also highlighted. Some advisers questioned the economics of targeting fertilisers precisely, arguing that in continuous cereal situations experimental data shows that within the range of N applications 200-280 kg/ha for instance there is only a £5/ha margin anyway. There is therefore little economic incentive to be precise. A further business problem highlighted was the dilemma of knowing how much fertiliser to order in advance, particularly as some farmers can spend up to £100,000; a fertiliser programme has to be made in the spring and it was argued that if fertiliser was targeted to crop needs, the farmer could finish up with 40t more than he needed. Fertiliser targeting also requires the farmer to be accurate with record keeping and monitoring as well as application, spreader calibration etc, some advisers consider this is beyond the abilities of some farmers who they regard as quite undisciplined.

RB209 is one guide available to advisers and farmers in the Landcare catchment to assist them with targeting N fertiliser recommendations. Advisers, farmers and researchers, however, have different views on its value. Rather than choose a tool for its scientific accuracy or for its best management practice credentials, farmers and advisers tend to favour an N fertiliser recommendation system that provides an acceptable recommendation, has been derived locally and allows them to achieve the yield they expect. Recommended N rates from RB209 are considered by many cereal growers and their advisers as not relevant because they are based on a national average and do not allow high yields to be achieved. Those who want to achieve higher yields prefer different guides, which give higher N recommendations, as this comment shows:

If you're a serious cereal grower with potential over the national average, RB209 is not relevant. For example, for spring barley it suggests no more that 225 kg, most of our farmers use 25 kg above that because it's more profitable (Independent agronomist PS).

However, some advisers and farmers interviewed argued that fertiliser targeting does not have to be impractical, that it is 'small hassle' and that they would give most fields a different rate anyway because of different soil types, variety types and yield expectations; and with liquid spray it is quite easy to adjust spays. Equally some farm management advisers see the blanket fertiliser approach as outdated for larger farms and argue that progressive thinking farmers have been targeting fertiliser for a number of years to avoid waste and reduce costs. However, although supportive of the principles of N fertiliser targeting, some still have issues about how to achieve it. For example, some advisers were critical of the revised RB209, because of its size and format which they claimed made it unworkable for larger farms. Also, because RB209 was developed by DEFRA, it is considered by some to be part of a wider government agenda to cut down yields. The following comments made by a representative from a large and respected Farm Management Company, which manages and advises on a number of farms in the catchment, demonstrate that even the more committed advisers have some reservations about N fertiliser targeting.

Our concerns with these tools is that they put you more into a straight jacket and RB209 becomes less of an adviser' tool and more of regulatory tool. In the future, if RB209 is a bible, we will struggle.

RB209 is one of the most shocking documents ever produced, practically unworkable. Nothing wrong with what it says but no one in their right mind is going to plough through it (Farm Management Company representative).

Using the nutrient value of manures: advisers' contribution

A large part of the promotion of soil best management practice in the Landcare catchment has been aimed at using the nutrients within manures as part of the nutrient budget for the farm. The ADAS Managing Livestock Manure booklets have been promoted at Landcare workshops and form part of this campaign. Using the nutrient value of manure requires some understanding of nutrient dynamics in the soil and being able to estimate amounts, and the nutrient content, of manure, unfamiliar skills for most farmers and their advisers, for example, one independent agronomist (PT) said *'Well who can cope with manures? You have to make a stab at it and estimate what's going on'*. Interviews revealed that adjusting nutrient budgets to allow for nutrients supplied in manure applications is still very challenging for advisers. Although advisers have built up experience recommending N, they do not have the experience of high fertility situations where organic manures have been added:

I appreciate that N applications and getting the rate right is one of the most difficult things we have to do as advisers and this is particularly the case in cases of high fertility where manure or sewage sludge are added. What we're doing, advisers and farmers alike, we're all scratching our heads asking how much should we allow for that? (Independent agronomist EB).

Agronomists consider that their locally derived knowledge provides a reference point in normal situations but this becomes less effective when circumstances become unfamiliar. This was also revealed by interviews with advisers in the SUNDIAL-FRS case study. The following remarks demonstrate the problems advisers encounter:

You could say that in known conditions with a regular arable rotation there is an intuitive level which we could establish with a reasonable level of confidence but in high fertility situations, this is where we come unstuck and struggle (Independent agronomist PT).

Yes so your local knowledge and experience helps you with normality because you know where your bench mark is but it's when it becomes unfamiliar and it happens outside anyone's control (Independent agronomist LS).

Views expressed by advisers show that while the number of farmers who practice manure nutrient budgeting is increasing, many have yet to acquire the skills. A number of advisers see that ignorance of the value of manures as an obstacle claiming that the majority of farmers still regard it as a waste product that has to be disposed of rather than as a valuable source of nutrients. One adviser working in the Landcare catchment described nutrient budgeting as a 'closed book' to 95% of farmers. He argued that only the larger arable farmers are taking an interest (with perhaps only 5% of farmers and 15% of land being subject to a nutrient balance).

Bigger growers are thought to recognise it as a way of reducing costs but these are in the minority. The biggest problem comes with small mixed farms in the Landcare catchment, for example, those with maize, which become a dumping ground for manure, such farms are thought to end up having too many nutrients in the system, as an ESA Project Officer (A) remarked '*You're getting vast quantities of P and K, almost 'pump and dump', you're getting 2-3 times the crop's requirements in many cases*'.

Advisers often lack basic information on which to base their advice because of the farmers' inability or reluctance to measure the amounts of manure used. Advisers claim that manure applications are roughly estimated, spreaders are uneven and manures are often mixed from different animal sources, leaving the agronomists uninformed. As one independent agronomist (DG) said '*Manure is not an exact science, show me a farmer who uses a weighbridge when he applies manure*'. One independent agronomist (CH) outlined three problems with farmers and FYM. Firstly she argued they don't know how much they put on, they can only say a light or a heavy dressing, secondly they don't know the manurial nutrient value and thirdly, they are not aware that to spread it and leave on surface and plough in a fortnight later is not an option as a lot of its value is lost. An ESA officer operating in the catchment shares a similar view:

They don't know what's in it in many cases, haven't a clue what the analysis is, they are reluctant to do analyses whether slurry or solid, they haven't got a clue as to how much they put on. The whole thing is very hit and miss, another aspect is that spreaders are very hit and miss as well (ESA Project Officer A).

Another difficulty is that researchers and farmers often operate with different units, as revealed in SUNDIAL-FRS, some farmers even using their own individual units, one independent agronomist (DG) described '*A farmer I worked for was a great muck spreader, when asked how much he wanted on a particular field he replied 'just give it a sniff'*.

Given these difficulties in utilising this soil best management practice it is surprising that 82% of questionnaire respondents claimed to be recommending the use of nutrient value of manure. Researchers, however, argue that estimating nutrient content of manures should not be a barrier, that there are different scales of effort farmers can go to. They claim that manure does not have to be tested, as standard tables can be used as a default to the nearest common denominator and that very clear booklets are available. They complain that farmers are far more concerned with chemicals. They argue that all farmers have a weighbridge so weighing manure is easy, if they want to do it, as one said '*it's not rocket science*'. They consider that the MANNER PC programme is simple and easy to use. The comment below shows how ADAS researchers regard MANNER as a useful starting point:

We never promoted MANNER as all singing and dancing, it gets the answer in the ballpark and you can make a judgement on the back of that. The truth is MANNER is dead easy, it's easy to use and a lot of the technical stuff is in the background. Farmers don't have to answer too many questions, the hardest one is 'How much manure do you put on?' The consultants like it because it's easy to use... easy to use that's the one thing it's got to be or you needn't even start (ADAS adviser C).

Advisers do recognise that many of the more progressive and bigger farmers are more disciplined about accounting for manure, measuring its value as part of their nutritional programme. Increasingly farmers are buying in manure, sewage sludge or poultry manure, particularly arable-only farms or those on thinner soils, and they have seen big benefits and saved money. Advisers described some of their farmers as realising the economic sense of taking manure into account when they fertilised. This is restricted to larger farmers however, who use more sophisticated spreading machinery and are usually taking advice from well-informed agronomists. Farmers themselves also described the benefits to soil and the cost savings, as the remark from a Landcare farmer below suggests. These changes vindicate to an extent the researchers' approaches towards manure nutrient use.

Yes definitely we estimate how many tonnes of manure and where it went on. Where I put a lot of manure on last year, I put a lot less N top dressing on, so it's helping me again and saving me money. For the soil structure and composition, I'm sure manure is all good (Farmer MF).

6.5.3 Landcare: summary and discussion

The results from this case study demonstrate that advisers, rather than accepting unquestioningly the soil best management practice promotions from the Landcare project, negotiate, contest and transform them. Observations, practical and financial considerations, individual agendas, skills and competence and locally derived knowledge influence these processes.

Advisers argue that practices promoted by Landcare highlight a lack of understanding of farming constraints. They also consider that there is a lack of competence both within adviser and farming communities to support these more knowledge intensive practices. The difficulties advisers face in recommending cultivations, N fertiliser and estimating the nutrient contributions from manure demonstrate these challenges. Advisers suggest that researchers fail to understand the financial imperatives, which drive farmers' decisions. The practical constraints of implementing a targeted and synchronised fertiliser management system are also seen as a major drawback, as they demand more labour, more time spent recalibrating the tractor and expensive soil analysis. They also require quite sophisticated monitoring, beyond the capabilities of some farmers. Advisers themselves also may lack sufficient experience and knowledge to advise on targeting N. In addition the perceived 'green agenda' associated with tools such as RB209 makes these tools less acceptable to both farmers and advisers.

In terms of managing manures, advisers claim that researchers fail to understand the pressures farmers operate under in dealing with waste. They stress the unavoidability of farmers' practices due to weather, land and labour restrictions, farmers' general lack of understanding of using soil N dynamics and lack of confidence in the results of estimates and analysis. Agronomists place a lot of reliance on locally derived knowledge and experience as a reference point for N recommendations but these fail in unfamiliar high fertility situations where manure has been added. They also lack adequate information from farmers on which to base their advice, which further frustrates the process of achieving best management practice. Estimating amounts, and the nutrient content, of manure are unfamiliar skills for advisers and most farmers. This concurs with results from other studies which found that farmers lacked confidence in using manure analysis because they found results to be so variable as to make analysis 'pointless' (Smith et al. 2001, 2002). Similarly farmers in focus groups run by ADAS said they reduced their fertiliser accordingly when using manure but on very conservative estimates, many said they could not risk a crop on predicted nutrient values or on an equally dubious set of analysis results (ADAS 1998). However, results from the DEFRA Farm Practices Survey (DEFRA 2002c), showing that 38% of specialist cropping farms and 15% of cattle farms with crops used lab analysis to estimate slurry and manure nutrient content, suggest that, as revealed in this case study, some farmers and advisers are beginning to account for nutrients in manure. This vindicates the researchers' view to some extent showing that, for some farmers at least, using manures as a source of nutrients is not '*rocket science*'.

Nevertheless most farmers and researchers attribute different values to manure. Whilst researchers regard manure analysis as a scientifically valid instrument for farmers to gain better soil nutrition and economic benefits, many farmers see manure as a waste product requiring disposal. Advisers must negotiate these two perspectives. Although they appreciate the principles of using manure nutrients they witness, and sympathise to some extent with the '*pump and dump*' of manures as farmers desperately try to dispose of it. Comparison of the ADAS Managing Livestock Manure booklets, which sets out precise calculations for the analysis and weighing of manure, with the farmer who wanted to add '*just a sniff*' of manure to his land, exposes the divide that advisers need to be cross.

The picture is slightly different when it comes to cultivation and soil management. Whilst the farmers are most experienced and skilled in these operations, advisers lack such experience. Consequently they tend to lack confidence and expertise and this is seen as hampering good soil management. Advisers recognise that it is the farmers who have to make the decision on the day when they are not present and they are reluctant to intervene in operations they are unfamiliar with. This concurs with observations by Parker and Sinclair (2001) who distinguished the types of decisions farmers and advisers make, the former making more theoretical judgements about when to cultivate or spray while the latter ultimately deciding the date based on the demands of schedules and the weather and carrying out the operation. As well as lacking competence in cultivation, the pressure to achieve planting schedules and fine seedbeds from some agronomists can actually lead to untimely cultivation and consequent soil structural degradation and soil wash.

In conclusion, this case study reveals that advisers' utilisation of soil best management practice research outputs is not uncommitted; more often than not they challenge these practices arguing that they are inappropriate for the practical community. They take the farmers viewpoint and become the farmers' voice in contesting the relevance of these practices. The lack of competence and confidence in certain skilled areas such as cultivations, N targeting and using the nutrient value of manures also emerges as a critical area, which has implications for the promotion of soil best management practice. Thus the patterns of utilisation indicated by the questionnaire analyses should be considered in the context of these case study insights.

6.7 Adviser response to best management practice messages: UK Soil Management Initiative

This section provides an analysis of the Soil Management Initiative (SMI) case study. It presents an in-depth examination of the factors that influence the advisers' utilisation of soil best management practice promoted by this initiative.

6.7.1 The debate between ploughing and reduced tillage protagonists

The aims and principles of SMI have been explained in Chapter 4. Although concerned with soil management, the public perception of SMI is one of an organisation promoting the benefits of reduced tillage[61] and much of the subsequent discussion covers this practice. Reduced tillage and ploughing differ markedly from one another and professionals and farmers generally have very strong opinions on their respective merits and benefits, often describing it as a very black and white issue. Replacing ploughing with reduced tillage involves a considerable change on

[61] Reduced tillage and minimum tillage (min-till) are used synonymously here.

the farm and can have profound repercussions for the whole farm business. Reduced tillage is being promoted by a few strong and vocal personalities who are accused by some advisers of pursuing it single-mindedly, in some cases inappropriately, and of being influenced by a commercial agenda. This makes it a controversial practice and SMI an organisation open to criticism both from within and outside its membership. At its most extreme, opinion is polarised between the two camps 'ploughing' and 'reduced tillage', as one independent agronomist (P) explained '*You're either for or against it; there is no room for grey areas*'.

6.7.2 Advisers outside SMI: perspectives

Most criticism of SMI, and the reduced tillage it is associated with promoting, seems to come from agronomists not involved with the project who are cynical about what they see as the single minded promotion of reduced tillage as the unquestionable answer to all the farmers' problems, as an independent agronomist (GB) remarked '*One thing is if you don't minimum tillage you're not going to go to heaven*'; another (T) said '*If you do minimum tillage you will enter a life of eternal bliss*'. Cynically advisers dismiss SMI as politically and commercially motivated, trendy and offering a quick but inappropriate solution to farmers needing to save costs.

I think SMI is the biggest waste of time and money that I've seen for a long time. People now running SMI have forgotten their scientific base of where they came from particularly X [SMI board member]. No it's politically acceptable to go for minimum tillage and that's where the SMI is going because it's PC, nothing to do with science (Independent agronomist EB).

The public image of SM as one mainly concerned with reduced tillage is attributed to the fact that the initiative has a number of powerful machinery and agrochemical firms within its organisation like Monsanto, Vaderstad, Simba and Syngenta who would benefit commercially from machinery and herbicide sales by greater use of reduced tillage within the farming community. Consequently SMI is often accused of having a commercial agenda. The comment below shows that SMI members acknowledge this perception.

There was a strong perception that SMI was there as a vehicle to push minimum tillage, it was never our intention to do that but that's perception isn't it. SMI is not totally focused on min-till but it's what some of the members want to see because they have an interest in it (Board member C).

Advisers are suspicious about the involvement of Simba and Vaderstad who sell drills and other specialist equipment needed for the transition to reduced tillage, and about other SMI members, Monsanto and Syngenta, who benefit from herbicides sales, as one independent agronomist (EB) noted '*They want you to minimum tillage to get the Black Grass to grow so you can use two of their products, Roundup then go in with Avadex*'. There is evidence also of aggressive marketing to convert farmers to reduced tillage, half of the examples given in the questionnaire of incidences where advice had been contradicted referred to situations where reduced tillage was being promoted by machinery and agrochemical representatives, against the advice of the regular adviser.

Advisers have wider concerns as well. The main argument for farmers changing to reduced tillage is to save energy costs. Although proven on experimental plots and in some case studies (Jordon et al. 2000), this cost differential between plough and reduced tillage is disputed. Advisers argue that it is influenced by soil type, being greatest on heavy land but insignificant on light land. In addition some suggest that because of heavy investments in new machinery the cost benefits are questionable for farmers unless they are at a point where they need to reinvest in machinery. Also they point out there are heavy penalties if the farmer buys the wrong piece of machinery. Agronomists also consider that there are unresolved agronomic problems that have to be understood before reduced tillage can be fully embraced. One of the biggest concerns is the prevalence of Black Grass and Sterile Brome weeds, the seeds of which are buried mostly by ploughing, but not always dealt with effectively by herbicides in reduced tillage. Many believe that if reduced tillage use spreads in the country it will make an already serious weed situation much worse.

Most of SE England not having a plough on the farm is recipe for disaster. I find some aspects are not easy to apply on farm. The emphasis on minimum tillage as a god is ridiculous for us on Heavy Boulder Clay in Cambridgeshire where Black

Grass is completely out of control. So I have some reservations about it. We keep the plough going once to twice in a three year rotation because of weed problems (Independent agronomist LS).

A key concern of advisers is that farmers are attracted to reduced tillage for the wrong reasons and are not sufficiently informed or competent about the operations involved, as one agronomist said:

What I'm most keen on is that they don't go into it blindly attracted by the big shiny pieces of metal. It's [reduced tillage] fashionable and it's trendy and farmers are looking at ways of saving time and money on cultivation but they are not really thinking about going back to basics enough, not using common sense enough, they think that minimum tillage is a quick fix solution and it's not, it's not a solution at all for a lot of people (Independent agronomist CH).

Advisers regard their cautiousness as justified because they argue they are the ones out in the field everyday witnessing the farmers failing with reduced tillage. Some refer back to former experiences and draw parallels with the promotion of direct drilling in the 1970s, which was seen by some as '*an unmitigated disaster*', leading them to refer to the current promotion of reduced tillage as having gone '*full cycle, like a revolving wheel*', or as one distributor agronomist (GB) remarked '*We've seen it all before, we don't want do go down that road again*'.

Another source of contention is the evidence about reduced tillage presented to the farming community. Much of the debate within the agricultural community about the benefits of reduced tillage centres around the validity of the evidence, in particular the extrapolation of research plot results to practice, and the validity of 'anecdotal research' contributed by the practical community. The principles of SMI are based largely on results from experimental plots at Long Ashton, which demonstrated the benefits of reduced tillage to soils and the environment. Critical advisers argue you cannot extrapolate from these experimental conditions to farmers' fields where conditions are very different, soil types in particular. They also suggest that researchers are often out of touch with the reality of farming, as one independent agronomist (EB) said '*He [SMI researcher] has never been a farm adviser and seen* *the sharp end*'. Experimental plots are criticised as having the luxury of not being constrained by any practical limitations, they often have easy soils, researchers can drill whenever they wish, and plots are small and have no economic constraints. As one SMI board member acknowledged:

We all had criticisms from farmers who would come to my site and say things like 'oh yes you can do that because you've got grass in your rotation' or they go to B [board member] and say 'oh yes you're a small farm you don't have black grass you can do that, if you wanted to sow one field on 12 o'clock on a Friday you could actually do it but if you've got 5000 acres to be sown it wouldn't work' (SMI board member A).

Advisers also challenge the benefits that SMI claim and argue that inappropriate reduced tillage can also cause soil structural damage and compacted surfaces and that sometimes more N fertiliser is needed because of slow mineralisation of the straw. Another major concern is farmers' inexperience with what is a highly specialised set of operations. Advisers have observed farmers' mistakes, which have resulted not only in yield losses but also in structural damage to the soil. Although aware of evidence from research plots, advisers have to reconcile this with their own observations and concerns. Advisers are convinced more by observed differences in farmers' fields, they place a lot of value in observation and much is learnt through regular informal inspection.

Although many advisers expressed a strong negative opinion about reduced tillage, some had a more moderate view and considered that reduced tillage did have a place if done appropriately for certain farming systems and in the right conditions, as one Environment Agency representative (B) said *'A healthy soil is essential for fertility and good crops nobody disputes that. There are agricultural practices that can enhance or degrade the soil. Min-till is only one way of tilling soil*'. Indeed some advisers were very supportive of reduced tillage and keen to learn more.

6.7.3 Advisers within SMI: different perspectives

SMI members[62] attribute bad experiences with reduced tillage in the farming community and advisers' poor attitude towards reduced tillage to their lack of experience and competence in this practice and in cultivation generally. Reduced tillage is a knowledge intensive practice requiring constant observation and monitoring of soil and crop conditions, it is thought by most advisers to be more difficult than ploughing. It is a practice that requires a lot of input from a competent expert especially if the farmer is inexperienced, particularly during the transition phase. One adviser involved described how he talked farmers through saying things like '*that soil hasn't got a subsoil problem... put the cultivator 3-4 inches down... that's a nice tilth on top... you're not going to bail the straw*', etc. A SMI board member talking about the IFS project demo farm similarly found that very clear instructions were sometimes necessary with such an unfamiliar practice until the farmer becomes confident, and starts to make his own adjustments.

In our pilot demo farm in Cornwall the farmer agreed to let me have 6 fields. I told him what he was going to do, he said 'no I can't do that', I said 'no listen to me; we've rented these six fields. I will tell you what to do'. They weren't happy but we talked it through and he did it (SMI board member B).

Reduced tillage is considered to be unfamiliar to the majority of advisers as they do not have the practical experience of cultivation, do not have enough clients doing it to build their experience from, nor are they present on the farm when timely decisions need to be made about tillage. Consequently it is argued they are not confident with it and can often be very critical about its inappropriate use. This remark from an SMI member describes the problem faced:

Some agronomists have had a bad experience with minimum tillage and they can't cope with it so they are very anti and all their farmers traditionally are ploughers and they won't have anything to do with it at all (SMI board member A).

[62] All board members contribute in some way to advice provision.

Farmers practising reduced tillage often commented that they know more about it than their advisers do and lack of support from, or cautiousness expressed by, advisers can frustrate them. Enthusiastic farmers can take the initiative and in these situations the degree of advisers' support can vary. Some advisers do not support some farmers' decisions and friction can result.

We had an independent agronomist whom we got rid of because he wasn't, he didn't like it [reduced tillage] at all. He was very critical of what we did and it was hopeless, all we did was argue about it. I said this is what we are going to do and he'd say 'well I can't back this I can't back that'. Any way we parted company and I'm going to get myself BASIS trained and I can do it myself. I think it's a whole new ball game (Farmer SMI board member D).

Farmers find many advisers cautious and ill informed about reduced tillage. Consequently, like the SMI farmer quoted above they are going ahead and learning themselves without advisers' inputs. They experiment individually, sometimes joining discussion groups to share knowledge or simply looking over fences. SMI, the Lo-Till advice line and Lo-Till farmers club are used as further sources of information and support. Advisers tend to be excluded from these networks. Some farmers also are secretive and regard advisers joining their discussion groups as potentially stealing their information and selling it on to other farmers. One adviser interested in reduced tillage commented '*I have been trying to get on that farm for 12 years now*' referring to a farmer who was effectively using reduced tillage but was reluctant to share the secrets of his success.

SMI project members regard lack of skills and experience in the advisory community as the biggest drawback in promoting reduced tillage and soil management as the comments below suggest. They also pointed out that agronomists do not appreciate that it involves a complete change of system and approach and erroneously believe they can use the same agronomy and cost structure for reduced tillage as for ploughing.

The thing is in some of those situations it's failing not because it's being used inappropriately but it's been used with inappropriate guidance. We don't have the *experienced agronomists to provide the helping hand; we have information but not the experts* (SMI board member B).

There has got to be a much better informed adviser group in this country able to look at farm and interpret and ensure they are using the right equipment and discuss with farmers in a knowledgeable way which way their cultivation should be going. At moment an awful lot of farmers suck it and see (SMI board member E).

SMI members described the natural intuitive reaction to reduced tillage by most advisers is to reject it in favour of staying with the 'tried and tested' practice of ploughing of which they have years of experience. This same conservatism is shown by many farmers with regard to reduced tillage as discussed in Chapter 7. This farmer's comment shows that risk of failure for their clients determines advisers decisions as much as anything else:

Farm advisers I know from personal experience they don't want to see too many changes happening on your farm because it's another problem for them, if you plough your land and do a conventional cultivation system it takes quite a few problems out of their hands. If you get a crop failure you're not going to come back to them and say 'I think your advice is bad because you advised me to min till it and look at all the Black Grass I've got and this that and the other' and I think there has been an element of advisers being very wary of making changes (Farmer SMI board member D).

These remarks suggest that we should view the data from the questionnaire with caution. Results showed that 70% of respondents had recommended reduced tillage is the last 2 years. It is clear from this case study, however, that this advice will be of variable quality.

It was suggested by some that farmers' interest and enthusiasm is the key to change as this will spur the advisers to find out more information on the subject. Members of SMI support this view as they see an increase in agronomists coming to them for training on reduced tillage because their farmers are asking for advice. Pressure on advisers to stay up to date and help farmers save costs is acknowledged by a number of advisers, such as the FWAG adviser commenting here:

It soon spreads if you have a switched on agronomist who is working on the farm, and they're reducing the inputs and still getting the same sorts of outputs and they go to their own agronomist and say 'how come he's getting away with that and you're making me do this? (FWAG adviser A).

In terms of the validity of the evidence SMI presents to the practical community, some SMI researchers put great store in results from replicated experimental trials and dismiss anecdotal evidence as not scientifically robust. The principles of SMI are firmly grounded in formal research trials and some members are reluctant to consider any anecdotal evidence which contests it, as one board member (B) explained '*People who do un-replicated experiments and a few observations and draw conclusions, which are not scientifically validated, that's what we're up against*'. In answer to advisers' criticisms other SMI members accept that replicating plot findings on farmer fields has been difficult, as the comments below show. These members recognise that experimental and practical farming situations are different, and accept criticism that plots are not subject to the pressures that normal farmers face.

It's putting a practical slant on a lot of it, we know the theory, we know that it can be done in a plot situation, Long Ashton have done these things and the results have been fantastic. We all ought to be doing what they are preaching but actually getting it on the ground in practical situation doesn't always work that well and that's the gap at the moment, the gulf we've got to fill somehow (SMI Farmer D).

In recognition that formal experiments do not always yield practical results some SMI members expanded the experimental network to cover a larger area, so defending themselves from advisers' criticism, as one member explains:

By bringing in 9 trial sites we were able to replicate a huge series of problems so when people came to us and said 'oh yes you can do that' we were able to say to them 'go to that site they've got the Black Grass problem' or 'they've got this and *that' it gave farmers the opportunity to look at the alternative and gave us some defence* (SMI board member A).

An SMI member (adviser/researcher) working on experimental plots described the difficulties of trying to please both farming and research communities. Working on cultivation trials they found that when they used a more academic approach, that it was impractical, it delivered the benefits they were looking for but it was not adoptable by farmers. They then approached it from the other way around and looked at what farmers had by way of machinery and how they could use this in a better way. This 'middle way', however, was not without criticism, as he explains:

We were informed from both directions and of course got criticism from both directions. You know from the scientific community who said 'oh well you're not going far enough' and from farmers who said 'you're going too far', but you always get that, different shades of opinion. (SMI board member A).

6.7.4 Advisers within SMI: different agendas

Membership of SMI includes farmers and representatives from ADAS, Monsanto, Allerton Trust, GCT, commercial agronomy firms, farm management companies and the Environment Agency. All contribute in some way to advice provision, either within the project or as part of their professional work. This range of backgrounds and objectives can lead to different personal agendas amongst SMI members and some misunderstandings. In very general terms those from a commercial background (Monsanto, Syngenta) regard it as an organisation promoting reduced tillage and those from a non-commercial background (ADAS, Environment Agency) see it as an organisation promoting soil management. This has a strong impact on the messages going out to the practical community. There is an acceptance amongst them that members have different agendas, and that each member might well give a different account of the objectives of SMI.

Yes we do have different agendas and there is no question of hiding that and we sometimes joke about it within groups, because of course Monsanto, Syngenta, Simba and Vaderstad and are not members of SMI because they are particularly *keen on sustainable soil management. It's a factor but other drivers are behind their interest* (SMI board member A).

Some members are more critical than others of the commercial sector of SMI and have concerns about the machinery manufacturers' involvement because of their very strong marketing tactics and their history of selling excessive and unnecessary reduced tillage equipment to farmers, as one board member (D) observed '*Some farmers were buying a quarter of million pounds worth of kit, whereas actually you can do it for £30,000*'. The emphasis given to reduced tillage is a key area of contention within the membership. One non-commercial board member has strong reservations about what he saw as SMI '*preaching the wrong message*' and was described as '*championing the plough*'. He is a dissident among the membership and was described as having '*a foot in both camps*'. He is informed mostly by observations and farmers' comments about the negative effects of reduced tillage on the soil, which some SMI scientists find unacceptable as evidence. Despite these different views and agendas, SMI claim that having an extensive '*broad church*' membership representing all factions prevents any particular vested interest steering it in any one direction. They believe the benefits of working together outweigh the disagreements, as one board member (C) explained '*We have some great arguments sometimes but there is huge amount of commonality, that's the reason we're working together*'. Also, aware that the SMI image is one of an organisation promoting reduced tillage, board members are keen to consolidate the message and the diverse views of the board.

There are members that are very pro non-plough tillage of course and there are those that are the other way, I'm somewhere in the middle. I believe that a rotational plough is a useful thing to include in your operations. What we need to do is first of all make the message clear that SMI does not preach min-till as its only objective and we need to get a better understanding of what actually we are talking about when we talk about min-till. We also need acknowledgement from members of SMI who are anti-plough that that is not a helpful stance to take either, that flexibility remains the key, I think that's what those in the middle ground would say (SMI board member A).

It's important to say that SMI is for soil primarily and within that you've clearly got what can I do for the ploughman, what can I do for the minimum tillage man and what can I do for the direct drill man? (SMI board member C).

Clearly the board members acknowledge that SMI are not presenting a unified message. They recognise the importance of being more flexible, and that any emphasis on ploughing and reduced tillage as polarities in competition distracts from the key message about soil management.

6.7.5 SMI: summary and discussion

The results reveal that a number of advisers perceive SMI as an organisation promoting reduced tillage and question the efficacy of this practice; consequently rather than accepting SMI promotions, they negotiate and contest them. Tensions within the agronomy community emerge as individuals join the debate, which is polarised between the pro-plough and the pro-reduced tillage factions. Different agendas within the SMI membership also mean that negotiations are taking place motivated by competing commercial and environmental interests.

Advisers are cynical about the commercial motivations of the members, have concerns about the agronomic problems associated with reduced tillage such as weeds, and believe farmers do not have sufficient competence or understanding to practice this very complicated and demanding management. They also question the validity of the research on which the project is based, claiming it does not extrapolate well to practical farming situations. In response, SMI members suggest that advisers are cautious and risk averse and that advisers' inexperience in cultivation accounts for their reluctance to endorse reduced tillage.

Different views of the validity of research outputs were identified. The principles of SMI are firmly grounded in formal research trials, a number of advisers, however, argue that experimental plot results are irrelevant to real farm situations as the management of a highly complex practice like reduced tillage is limited by practical day-to-day factors; factors which researchers fail to appreciate. Instead of formal research they prefer their own experience and observations to inform them and point to incidences where reduced tillage has failed to deliver expected soil, environmental and/or economic benefits. Some SMI members are reluctant to consider such anecdotal evidence, rejecting it as invalid and unscientific. Such tendencies for researchers to exclude traditional local knowledge, often farmers, have been described in previous agri-environment studies (Burgess et al. 2000; Wynne 1996). Both SMI and advisers outside SMI claim to represent the farmers' interest, while SMI advisers refer to facts and figures demonstrating cost savings and benefits to soil, critical advisers draw on their '*real world*' experiences. However, as the popularity of SMI increases and farmers are increasingly asking for advice on reduced tillage, critical advisers must reconcile these demands with their negative experiences. Disagreements also occur between SMI board members and where these have not been reconciled, tensions have developed which has implications for both the overall perception of the organisation and the soil management practices they promote.

Reduced tillage relies on experienced practitioners and involves continuous local observations and learning through practice. Advisers, in that they do not get involved in the day-to-day cultivation decisions or activities, cannot gain this necessary experience and consequently lack confidence and expertise in reduced tillage. SMI members and farmers alike highlight advisers' inexperience in cultivation as a major drawback in promotions of soil management generally and reduced tillage specifically and this has been noted in other studies (Tebrugge and Bohrnsen 2001). Farmers find advisers cautious and ill informed about reduced tillage because of their limited skills and competence and are consequently by-passing advisers and relying on their own on-farm experiments and 'learning in practice'. This observation concurs with Coughenour's (2003) and Hassenein and Kloppenburgs' (1995) findings in their respective studies of conservation tillage and grass rotations. They found that the formal advisory and research community were poorly equipped to support farmers in such knowledge intensive practices. Instead farmers learnt unsupported through experience and practice and created networks to convey this new knowledge between themselves; networks that tended to exclude advisers.

The results demonstrate that advisers' receipt of SMI best management practice promotions is not uncommitted but influenced by their observations, experience and skills, their confidence in the research base of the organisation and their trust in the organisation membership. These factors lead to negotiation, contestation and transformation of soil best management practice messages rather than simple acceptance.

6.8 Chapter summary and discussion

Although the results discussed in the first part of the chapter (sections 6.2 to 6.4) provide an overview of the extent and patterns of advisers' utilisation of soil best management practice knowledge within the AKIS, the case study results presented in the second half of the chapter (sections 6.6 to 6.7) reveal that advisers' processes of knowledge utilisation (like the acquisition processes) are embedded in social processes. They also demonstrate that rather than utilisation of knowledge about soil operating as a discrete process, it is bound up with acquisition, generation, integration and transformation.

The results from these case studies, as for SUNDIAL-FRS previously, demonstrate that knowledge processes at the interface with soil best management practice research and policy are characterised, not by knowledge transfer, but by continuous and interchangeable interpretation, contestation and negotiation of knowledge. Far from being neutral receivers and transmitters of information formulated by researchers, advisers reinterpret best management practice research outputs according to personal and collective agendas and professional allegiances. Advisers' acquisition, utilisation and transfer of knowledge is therefore not uncommitted. Transformations and negotiations occur as advisers wrestle to assimilate knowledge from new soil best management practice practices and ideas into their practical working lives and as they try to reconcile competing views and worlds.

Advisers exist at a critical point in the AKIS spanning boundaries between research, other advisers and farmers. Poor linkages at the institutional interface described in Chapter 5 explain fragmentation of the AKIS but this concept does not provide an understanding of the complex social processes actors engage in at these interfaces as they endeavour to bridge, accommodate or struggle against each others' worlds of knowledge. The concept of social interface which is concerned with discontinuities in social life (Long 1989) can be used to explain the different perspectives, life worlds or cultures that advisers, researchers and farmers operate in, and the discrepancies in values, interest, and often incommensurate forms of knowledge and the tensions that result.

These dissonances between different categories of actors involved in the production, dissemination and utilisation of knowledge were evident where groups of actors were brought together, as in the case study initiatives and partnerships. SMI, for example, as an organisation has to reconcile the views of the members, who champion reduced tillage, with those of members whose primary interest is soil management. Advisers currently involved in demonstration research plots have faced criticism from researchers and farmers and have to negotiate a path between the two. In the Landcare study the divide between the researchers' understanding of manures as a valuable source of nutrients and the farmers' view of it as a waste product; and the divergent understandings of the researchers and the advisers with regard to the validity of scientific and anecdotal research in SMI, provide further examples of the friction that occurs when conflicting professional and social worlds intersect.

These cases illustrate how advisers are caught in the middle of such tensions and have to work in a territory of contested meanings in which different actors, researchers, advisers and farmers struggle to establish or resist competing interpretations of soil best management practice. How these various tensions are resolved depends on the factors such as power, trust and understanding, both at the organisational and individual level, and the daily demands and practices in which advisers are embedded. Chapter 7 now turns to examine how advisers' negotiations, interpretations and transformations determine how and what knowledge is presented to farmers and how farmers interact with this knowledge at the adviser-farmer interface.

Chapter 7

ADVISER-FARMER INTERFACES IN THE CONTEXT OF SOIL BEST MANAGEMENT PRACTICE

7.1 Introduction

The previous two chapters were concerned with advisers' interfaces with the communities that research and promote soil best management practice. This chapter completes the examination of interface by focusing on the adviser's one to one interactions with farmers in the context of soil best management practice. The previous results demonstrated that knowledge processes were far more than technical efficiencies but also comprise social processes. They also revealed that advisers' knowledge interactions have to be situated within social and institutional interfaces for a complete understanding of advisers' knowledge processes in the AKIS framework in relation to soil. In addition the results showed that advisers often contest and negotiate knowledge about soil best management practice derived from research claiming that farmers would reject them on the basis of impracticality. This chapter investigates the origins of these views by providing a detailed examination of the adviser-farmer relationships and the knowledge processes that occur at the interface between them. Drawing primarily on analysis of interviews from the three case studies, it is concerned principally with agronomists as previous chapters have revealed that these advisers are potentially most involved in decisions on-farm that affect soil management.

The first part (sections 7.2 and 7.3) of this chapter describes the context of the adviser-farmer interactions, section 7.2 outlining the extent and nature of adviser use by farmers and examining the advisers' influence over farmers and section 7.3 exploring the conflicts advisers encounter as they try to resolve best management practice and client demands. The second part (sections 7.4 and 7.5) considers the knowledge processes at the adviser-farmer interface in detail; section 7.4 examines the interpretations, negotiations and transformations of knowledge that occur as advisers and farmers make adjustments for local farming conditions while section

7.5 is concerned with the elements of facilitative adviser-farmer relationships that enable knowledge integration in the context of soil best management practice. The chapter concludes with a summary in section 7.6, this is brief as further analysis and discussion of these results is provided in Chapter 8.

7.2 The agronomists' role in influencing farming decisions

7.2.1 The changing nature and extent of the agronomists' influence on the farm

Extensive use of agronomists, crop consultants and trade representatives by farmers and their close and regular contact makes them important players on the farm. Agronomists are widely used by cereal farmers, with 80-90% of farmers using agronomic advice of some kind according to estimates provided by some interviewees. Whilst some suggest that the majority of these farmers would use an agronomist mostly for agrochemical advice others considered that the depth of advice provided goes far beyond crop protection for a number of farmers. Some, like those commenting below, describe a heavy reliance on agronomists.

An awful lot of crops in this country are not farmed by farmers but farmed by advisers. These days farmers use advisers but they are just being lazy they don't really need them (ARC representative N).

I do nearly all the rotations, I don't know why, I shouldn't need to, I mean what the hell do farmers do? What do they actually do? (Independent agronomist DG).

Agronomists have become more important and influential on the farm in helping to alleviate the farmers' multiple pressures and are appreciated by all members of the agricultural community. Farmers describe them as a '*valuable member of the team*' or '*a very important person on the farm*' and the suggestion is, as the following comment explains, that they are very influential.

You have very strong influential power with the farmer, he has so many balls to juggle in the air, business as well as crops/livestock, just one more thing to think about is one too many, unless he's getting advice and direction from an adviser (Independent agronomist RB).

Some, however, question the nature of this influence as in many cases it is the farmer who sets the agenda, with agronomists having to work very much according to their clients' instructions. It is felt that some agronomists have become '*just lackeys*' to the farmer providing technical knowledge unthinkingly, as an ADAS adviser (B) observed '*The local agronomist tends to get rather sucked in by what his farmers think. He doesn't necessarily stand back and make objective decisions, meeting their needs*'. However, even for farmers who dictate the agenda or became BASIS trained it was suggested that they would still get an agronomist along to the farm for reassurance. It was also considered that some farmers, although they are already competent, want to achieve more and they continue to use an agronomist as a 'technical leg-up'. The style of this 'reassuring relationship' is described in the following remarks:

I decide pretty much what I'm going to crop where and then I usually run it by him and say 'look this is what I think I'm going do next year...these varieties'. He usually just says 'yes that's fine' or 'have a think about this'. He just gives a little bit of input, that's all I'm looking for (Farmer M).

One of the things we begin to see that a lot more of our growers are actually farming their own crops. They are looking to do more of their own agronomy to take those costs out of the system, take the service charge off the can. But they would still get the adviser to make sure they are on the right track (ARC representative N).

7.2.2 The one to one relationship between agronomists and farmers

The agronomists' influence is attributed both to the extent of their contact with farmers and to the close nature of the one to one relationship, which often involves walking the farm together on a regular basis, for example, one distributor agronomist (TB) remarked '*The adviser has the farmer's ear whilst they are going around* *looking at crops*'. Farmers like having an agronomist on the farm to check practices as well as explore some new ones with them. As such, agronomists become the farmers' 'sounding board' or confidant.

Farmers work much more closely with agronomists than they do with advisers. Often they are the first person they will talk to if thinking about going into a scheme and if they say 'no I don't think you should' then we don't get out there at all (FWAG adviser A).

Agronomists and farmers alike recognise that effective advice provision, although clearly dependent on good technical advice, is based on a good social relationship founded on mutual benefit, trust, loyalty, friendship, understanding, credibility and impartiality. The supportive role provided by some agronomists is much valued by the farmer, particularly as increasingly farmers are working alone on the farm. Often a close relationship or a friendship develops over the years.

It's also a personal thing as it's quite a lonesome job being a farmer. They just like to hear views from another person. It's seen as a very supportive role. Yes, it is very close, it's not only arable production, it's how's the wife and the family are as well (Distributor agronomist TB).

As part of this relationship farmers have complete faith in their agronomist's judgement, both in terms of specific advice, but also to the extent of leaving whole elements of farm decisions entirely to him, as these remarks demonstrate:

The relationship is based on a lot of trust. They trust you and they are very pleased to have someone they trust and in with that goes an acceptance 'Oh well I'll leave them to do that, that suits me'. There's no abuse of trust (Distributor agronomist TB).

Yes, your fate is in their hands. I have to say they play the most important role. You need to be absolutely happy the guy you've got is the right guy for you (Farmer P).

Trust and loyalty are key elements of many one to one relationships. Trust operates in both directions, farmers value advisers whose decisions they can trust and advisers trust farmers to carry out their suggestions, whether it is agronomic advice, RDS scheme plans or Environment Agency regulations, as one distributor agronomist (RB) remarked '*There's a relationship between us and them, which makes them come back to us and makes us committed to their crops*'. Time to establish a relationship is seen as a key component of trust and loyalty, and this is regarded as especially important in explaining farmers' acceptance of FWAG advisers. A trusting relationship is also a loyal one; agronomists rely on farmers' loyalty in keeping their customers. Having customers for 20 years or more is not uncommon as once the farmer has found someone they are comfortable with they tend to keep them, for example, one adviser (who has a family farm of his own) said:

Farmers are unbelievably loyal to their agronomists, unbelievably loyal. We employ someone at home but the last thing we want to do is lose him. They are farm staff, it's trust. We bounce ideas off, it's very trusting (ADAS adviser C).

Farmers do, however, demonstrate different strategies with regard to advisers, while some might remain loyal to the same adviser for many years, others employ two advisers on the same farm and compare their advice (as one interviewee did) or swap agronomists every now and again simply because they want a change or a different viewpoint, as one ADAS adviser (B) explained '*They think 'well I've had this guy for x years let's try someone else*''.

Advisers consider that being honest and transparent are also essential qualities. Distributor agronomists believe that being transparent about the rates of charging is important, while advisers promoting best management practice made the comment that there is no point in being subtle or devious about their environmental agenda as *'farmers aren't stupid'* or *'they see through it'*. Although distributor agronomists do have strong links with trade or other organisations, honesty is emphasised above everything else as important. They realise that they are perceived as working under a company and potentially perceived as having, as one said, *'to flog a certain amount of stuff'*. They are cautious about developing too strong a link with suppliers as they don't want to be seen to be getting *'too much in bed'* with certain manufacturers. Farmers respect this honesty.

At the end of day who ever you're working with or if you're an independent you have to do an honest job that the most important thing it just doesn't work if you're not (Distributor agronomist RB).

He's [his distributor agronomist] an extremely impartial chap. I've had him here virtually since I started; he's a close personal friend now. I don't think he's ever sold me chemicals which weren't needed. If we can do something through cultivation or some other way then we would (Farmer PP).

With trust, support and friendship comes a responsibility. Agronomists tend to see themselves as being on the farmers' side and having a role protecting them. They often talk about '*my farmers*' and defend them from criticisms or intrusions. This can be an alliance against the regulator, for example, one independent agronomist was described by another as '*the farmers friend, he's seen as trying to keep the Environment Agency away from them*'. Distributor agronomists often have stronger loyalties towards their farmers than to their employers and more sympathies tend to lie with the farming communities, as these agronomists suggest.

At the end of the day most agronomists are more dedicated to their clients, because they tend to become friends, than they would be to the concept of the company (Distributor agronomist RB).

If something doesn't work or kills the crops you feel responsible even if it was for understandable reason, you ultimately try and support that farmer and make sure he is fairly dealt with (Distributor agronomist TB).

Advisers are also concerned about farmers taking risks, whether it is with disease control or purchasing new machinery. For example, if a farmer adopted reduced tillage where the adviser had concerns he would make sure that the farmer had made arrangements to fall back on the plough if necessary. The SUNDIAL-FRS case study demonstrated how advisers acted to protect the interests of their clients. They managed the amount of time farmers spent with researchers quite sensitively making sure the farmers were not putting in more time than required, as one researcher (X) said '*The advisers were keen to look after their client relationship, in fact I suspect some of them felt after a while it [the SUNDIAL-FRS consultation] was past its useful point*'. The advisers had strong feelings about what they would allow on 'their' farms. The SUNDIAL-FRS researchers wanted to send a questionnaire to farmers but the advisers wanted it changed arguing that the questions were stupid and did not appreciate the practical implications, as this agronomist (N) remarked '*I put it to them that I would not want that questionnaire to go onto any of my farms*'.

However, although these comments characterise the adviser-farmer relationship for many, the nature of the relationship is changing. The traditional view of farmers and agronomists walking the field together is being replaced by use of the phone, email and fax because of the pressure on the farmers' and agronomists' time. This is much to the regret of some agronomists as this remark reveals:

Yes, there is an element of less contact unfortunately. You've hit a raw nerve, in that we are aware that that time contact is getting less and I regret that. They are very pleased to have someone they trust but it doesn't alter the fact that my contact time is less than it used to be. They are pleased for me to get on with it, it releases them, I'm pleased to do it by myself because it's quicker but I miss the little chats, it's sad but true (Independent agronomist TB).

Some regard the main reason for the decline in field walking with farmers as the pressure on farmer time and lack of interest, as this agronomist explains:

O God no! They [farmers] haven't got time for that [field walking], nor the interest. It used to be go and see the farmer, go out in landrovers and walk around crops, come back discuss it, write a report but there's no time for that. That's a sign of the times, the job is continuously evolving (Independent agronomist DG).

These two sections have shown that advisers are influential on the farm in terms of the extent of use by farmers, the reliance some farmers place on them and in the close nature of the relationship they develop with farmers. The next section examines how this influence might potentially be used in facilitating the transition to sustainable soil management in England.

7.2.3 The potential of agronomists to promote best management practice for soil

Despite changes in the nature of the one to one contact, the agronomist, of all advisers, remains important and influential on the farm, a fact recognised by manufacturers and soil best management practice projects. Monsanto for instance have decreased direct trade to farmers but increased their contacts with the distribution community recognising their role on farm, as a representative said '*They [agronomists] are not gatekeepers, but they are at the end of the day the main influence on farm*' (SMI board member C).

Initiatives promoting best management practice also appreciate the agronomists' influence and describe them as '*more vital than ever*' and as having a '*critical role*'; they recognise that they need to get them '*on side*'. They regard them as a useful vehicle for getting messages to farmers as they have access to a large number of farmers, regular personal contact, understand practical matters, and are not associated with regulation. ADAS, when delivering best management practice messages for DEFRA, also recognise this, for example, one ADAS adviser (C) explained '*The fertiliser guys, the merchants, the agchem boys, the contractors are such a crucial part of message transfer*'. They have started to provide workshops and training for the consultant community, notably for the revised RB209 and the MANNER PC model.

The way we disseminated MANNER was via the ADAS consultant network not via researchers. We got advisers on board and have got it in the hands of the consultants who are confident with it. I'm not having to convince the farmers; if I convince their consultants, I've got the farmers (ADAS adviser).

The influence of advisers and the need to engage them has also been noted by some Landcare partners, as the comment below demonstrates:

I think the broader advisory community is going to be a key player in promotion of best management practice because a very high proportion of arable farmers will get their agronomic advice from a third party. My guess is we need to get to those advisers at a very early stage, if they're not on side. Let's put it this way, a Landcare project officer, however good, will have less credibility than the farmer's regular adviser who he knows and trusts. You've got to get those two together at an early stage otherwise you're lost (ESA Project Officer A).

Some partners, however, had reservations about harnessing advisers to promote Landcare principles because their competence in soil best management practice is unknown, for example, an independent agronomist (SD) noted '*I have no problem with the idea [of using agronomists] but which agronomists are they harnessing? I'm not sure how good they are at these environmental issues*'. A number of advisers recognise the part they can play in promoting best management practice and connecting science and practice and tend to describe it in functional terms referring to themselves as an 'important link'; one independent agronomist (PT) explained '*That is a major role for us. If we are aware of relevant technical advances which can be incorporated in practical agricultural ways, we let farmers know*'. An ESA project officer (A) envisaged a similar role for himself saying '*I see that [being a link] as part of my role. As an adviser inevitably I'm a bridge between research and adoption and research and commercial practice*'. Other advisers however, although they acknowledge a gap in advice provision, have their own reservations about being used to pass on best management practice advice. Whilst some said they would be willing to assist with dissemination of messages if resources were available, others simply did not see delivery of DEFRA's policy as their responsibility; one independent agronomist explains:

I have a bee in my bonnet about this, everyone is very happy to hand over responsibility to agronomists for policing and for information transfer but when it comes to doing anything themselves they are not putting in the resources. They say 'you're the chaps on-farm you know what's happening, you do it'. We can't do that, we're not prepared to take responsibility for it (Independent agronomist JC).

Agronomists' impartiality in relation to best management practice and their trusting relationships with farmers are valued by some projects. A consultant contracted by the Environment Agency explained that when he undertook a soil erosion survey in the Landcare catchment he initially went around each farm with an Environment Agency EPO, then afterwards by himself. He received a totally different reaction when he was by himself. The farmers 'opened up' and gave the information he wanted, but were clearly not going to do that in front of the EPO. As such the Environment Agency working with Landcare recognise that agronomists can provide a more acceptable vehicle than Agency staff for conveying their messages. In the more sensitive meetings with farmers they used an agronomist to represent their ideas but from the farmers' perspective and found this avoided any confrontation, as an Environment Agency representative explains:

Rather than being a slanging match with Environment Agency, we'll get someone in who knows farmers. We found that when we [the Environment Agency] left the room they would bring out maps and say 'I've got this problem on this field' and 'I've done this and it has gone wrong' but they wouldn't tell us as the regulator about this (Environment Agency representative B).

This section has shown that agronomists can potentially make a contribution to the transition to soil best management practice. However, they have their own priorities and objectives, which are principally to provide a service for their farmer clients. The resulting conflict is the subject of section 7.3.

7.3 Best management practice: agronomists' conflict of interest

7.3.1 Agronomists: conflict in meeting different demands

The agronomists' role in promoting soil best management practice is not without tension. Although some see it as their responsibility to impart research and best management practice outputs to farmers they are equally aware that farmers are constrained in using these outputs by practical and economic factors. Advisers will inevitably differ in how they resolve these tensions; how much importance they give to best management practice for soil relates to their own objectives and principles. Agronomists, in that they are paid to service client farmers encounter the biggest tensions.

For many agronomists, whilst best management practice for soil is seen as important, their priority is to sustain their clients' farm business, as a distributor agronomist (TB) pointed out they may show interest but '*Clearly they have other objectives in terms of clients' businesses not to mention their own*'. It is an ideal to aim for sustainable farming which is profitable, although agronomists argue that they are not always compatible and there are inevitable tensions between environmental and cropping issues. Although sympathetic to best management practice agronomists feel that they can only support practical solutions otherwise their credibility and consequently their business or job is threatened. The overriding importance of providing practices that advisers can use with confidence is evident:

This is the nub of the issue, how you inform agricultural advisers with information they can use in confidence with their customer, that they feel will not leave them criticised and therefore loosing that customer, because if customer says 'I didn't make as much money as I did last year' they are in trouble (Environment Agency representative A).

Credibility appears to be a key issue in determining whether advisers support soil best management practice. Advisers and their farmers alike put great value in credible advice, this means practical, economically sound advice that achieves results. Loss of credibility through advising inappropriate or unworkable practices is a concern for advisers. In this context some question the win-win best management practice messages being promoted, as one explains:

I'm not convinced. I think there's a danger in that if you say it's all win-win you will lose credibility, because any good adviser or knowledgeable farmer will quickly perceive that there are hidden dangers from the point of view of crop production in this advice. They'll say 'Oh no it isn't' You have to be open about or it will bring the whole thing into disrepute. They'll say 'wait a minute if you tell me it's all win-win how I can believe anything you say' (ESA Project Officer A).

In commercial agronomy, quality and practicality of advice is paramount, where best management practices are thought to impinge on this they will not be recommended. Indeed they will be strongly rejected as this statement shows:

If we agree with the message we would promote it, if it is sensible and practical. But we had a LEAF member talk to us and we had to say to him after the talk a) it's not practical and b) it's totally bonkers, it has no sound basis in either farming, environmental practice or anything else. If you take it to a farmer you'd loose credibility (Farm management company representative RW).

Strongly linked to credibility is a risk of failure. Agronomists can be cautious in an attempt to avoid blame if something goes wrong on the farm. To avoid risk of poor yield they will tend to recommend some chemicals prophylacticaly; some advisers admitted that they will recommend a higher N rate than needed to be on the safe side, which is contrary to soil best practice principles, for example, one independent agronomist (N) remarked '*Very often I will give myself a safety net because if something fails out on-farm and you're the agronomist, it's your fault*'. Agronomists ultimately are paid to provide clients with the information they want, whatever their own knowledge and principles concerning soil best management practice; it is the farmer who decides on the standards of practice he wishes to adopt. Many farmers simply do not want to know about best management practice for soil, they have no interest or perceive this as conflicting with business objectives. Agronomists are sometimes reluctant to point out bad practice because farmers are the business clients and they do not take kindly to paying an adviser who criticises them. Agronomists, whatever their interest, are thus constrained by the farmer, as these remarks reveal:

To be fair, our own clients are advised to this standard [Soil Code] but it is up to the client to indicate the degree to which he wishes to pursue the environment agenda (Questionnaire respondent).

I know a hard nosed commercial consultant at the sharp end but if you get him to talk carefully he will agree that there are environmental things he would dearly love to advise everybody on but sometimes it's difficult because the farmers say 'I don't *want to know about that I just want so and so'* (Environment Agency representative A).

Soil erosion would almost have to stand out like a sore thumb for agronomists to say anything (Independent agronomist RW).

Agronomists need to keep customers and there is pressure on advisers to meet the demands of their clients, as one commercial representative said (S) '*The one thing that really bites is customer loyalty*'. The climate in which agronomists operate is also very competitive; a FWAG adviser (A) explained '*The agronomy industry now is completely cut throat, if an agronomist isn't any good, and isn't up to date, he's out*'. Agronomists cannot afford to be complacent or risk untested practices in such a competitive industry.

Advisers resolve these tensions between farmer demands for risk averse, credible advice and the exhortations of the policy/research community to recommend soil best management practice in different ways. The way they prioritise soil management depends to a large extent on their own understanding of, and engagement with, sustainable soil management. Many take the view that soil best management practice is not compatible with achieving profit under current economic constraints, for example, one independent agronomist (DG) remarked '*Ultimately when you're in an industry with its back to wall those things like the Soil Code and the manure booklets come very low down*'. Such advisers, agronomists and land agents, with only commercial concerns focus very much on the financial side of farming regardless of whether it compromises soil best management principles, as this farmer's comment shows:

I suppose I have a consultant who comes along and he just has his financial eyes on. He knows the best ways of making money from your business and may be there will be conflict there; he says 'don't put up a slurry store put your muck on the maize' (Farmer J).

The more traditional and established farm advisers/land agents in the Landcare catchment were reluctant to join the Landcare partnership because they believed that, by endorsing soil best management practice on their clients' farms, they were risking their clients' profits and therefore their competitiveness as an advisory firm. Similarly when a demonstration plot for Landcare was established on one of the large estate's farms in the catchment, the farm management company advising the estate, who had a purely profit-led approach, did not want any involvement, as the farm manager (T) explained '*They knew exactly down to the last penny how much money to get off the land and that was their job, that was what they had been asked to do*'.

Commercial research stations can also be instrumental in encouraging farmers to compromise best practice in the quest for profits. In relation to N fertiliser rates, one independent agronomist argued that Morley Research Centre's interpretation of the crop growth curves have a built in safety net of 40kg which enables high yields to be achieved but does not consider farmers' current needs to reduce costs nor the principles of targeting fertiliser applications. He described the difficult situation he found himself in:

I'm on the expert committee at Morley. I have had this argument with them before, we can't afford to have this safety net not with the value of crops at moment but if you recommend less than Morley and it fails. Obviously to the farmer you haven't put enough N on. You end up having to go some of the way the esteemed researcher advises (Independent agronomist AL).

As well as soil best management practice conflicting with advisers' need to deliver credible advice to meet farmers' business objectives, recommending these practices can also have financial and professional implications for the adviser himself. There is some reluctance by advisers to get involved in projects or the development of tools that offer free advice to farmers as these are seen to threaten the adviser's own role. For example, some view developments in decision tools like SUNDIAL-FRS with caution, as an independent agronomist (EB) remarked '*A lot of advisers guard their technical impartiality and integrity jealously. They are reluctant to surrender to another organisation. If it's a tool to help rather than to replace them they would endorse it*'. Similarly a consultant, an SMI board member, who contributed to the free Lo-till advice line run by Farmers Weekly Interactive, complained that this was undermining his own business and subsequently withdrew from the board. Other agronomists also consider that the expense of investing in new tools such as DSS in terms of cost and time taken to learn how to use them is something they cannot pass on to their clients. Those promoting the use of nutrient value of manure as a substitute for inorganic fertiliser realise that this has financial implications for those distributor agronomists who are selling fertilisers.

Clearly there are underlying tensions; the fertiliser company is a classic example of where there is tension with manures. They are all FACTS trained, they should be giving good advice but you hear all sorts of stories of it not happening, the fertiliser guy saying 'you can't rely on manures' (ADAS adviser B).

The questionnaire results suggest that these contrary messages to farmers from different advisers are not uncommon. The data reveal that 21% of all respondents had come across a situation where their advice on soil management to a farmer had been contradicted by advice from another source. Seven respondents cited the pressure on farmers from fertiliser representatives or agrochem/machinery manufacturers, while others involved issues of inappropriate subsoiling advice. Of all advisers, distributor agronomists had their advice undermined the most (38%), with independent agronomists (30%) and ADAS (26%) close behind. There were far fewer instances of this happening to conservation (3%) or RDS (5%) advisers confirming that it is the arable practices where most tensions exist.

However, despite these conflicts and commercial demands, a number of advisers do not think that there is a significant conflict and believe if you treat the soil properly you get a better crop, the ideal win-win situation, as one agronomist (questionnaire respondent) said '*It's not a problem, if you don't look after the soil you will go bust*'. Some advisers interviewed do not see any major conflict between promoting best management practice and their own agenda. Agronomists claim to be embracing environmental issues more and taking a wider interest in soil best management practice. This has been in response to an increased number of regulations and initiatives, and increased interest from their clients. A general change in attitude in the industry as a whole was described as a distributor agronomist (GB) commented '*No, I think we're all pushing in same direction. I think we all understand what* *needs to be done'*. Minimising inputs to sustain the farm business is seen to be key in the current economic climate. Ignoring these new imperatives and the benefits to the soil from these practices can put agronomists at a disadvantage in such a competitive industry, as one interviewee (Environment Agency representative A) noted *'If agronomists close their minds to the environment side and best management practice options they will be doing so to the detriment of their clients'*. Some agronomists even see their approach as superior to that of the farmers they advise, who are still constrained by attitude, practical and cost issues, for example, an independent agronomist (DG) remarked *'Actually there is more interest in advisers at a personal level of the environment than there ever is in their clients, especially now farming is just bottom line'*.

This section has described the tensions that some agronomists face in trying to meet the sometimes opposing objectives of their farmers' businesses and best management practice principles. Credibility, risk aversion and appreciation of the soil resource are central to how agronomists resolve these conflicts. Ultimately the extent to which they prioritise soil best management practice depends on whether they are confidant that soil best management practice will not compromise the farmers' profits or their credibility and whether they feel secure in their relationship with their farmer client. The negotiations and knowledge transformations that occur when practical constraints and objectives are overlain onto best management practice objectives in trying to achieve this credibility are discussed next.

7.4 Knowledge interpretations, transformations and negotiations at the adviser-farmer interface

7.4.1 Advisers' interpretations and transformations of knowledge about soil best management practice

The previous sections provided the context of adviser-farmer interactions; this section explores the knowledge processes that operate across the adviser-farmer interface in detail by examining advisers' transformation of knowledge (7.4.1), farmers' utilisation of knowledge (7.4.2) and finally advisers' integration of knowledge (7.5).

Knowledge does not stay the same as it moves from the research, policy or trade communities to advisers or from advisers to farmers. Each actor will have a different interpretation and perspective and they will negotiate and transform knowledge, modifying it with local knowledge and experience to make it relevant to their own conditions. In this process researchers both generate and transform knowledge by making selective interpretations of their results and by synthesising data from their experimental data to produce guides for use by the practical farming community, for example, RB209. Advisers in turn transform researchers' interpretations to turn them into practical farm-specific recommendations, and farmers continue this transformation by adapting the recommendations further through utilisation and practice. One independent agronomist (SD) points out the cyclical nature of the process saying '*Recommendations get changed by the researchers to meet farmers requirements then practitioners and advisers end up transforming it back again and it gets a bit silly* (laughs)'.

Advisers are central to such transformation, they add their own individual interpretations to research outputs which reflect their experience and personal agendas. This was demonstrated clearly in the case study analysis where advisers take research outputs and modify them using their own '*user knowledge*' and experience. In particular, advisers must assimilate the technical efficiencies of research outputs with the practical and business considerations outlined in the preceding sections. How they reconcile and balance these is an individual process and will determine the advice given, as an independent agronomist (N) remarked '*Experts can make good sense but when you overlay the practical issues of labour and machinery on farms, you have to come to compromise and different people compromise in different areas*'. Underpinning this are the individual discrepancies involved when dealing with heterogeneous farm soil conditions, as one independent agronomist (PT) pointed out '*Two people dig a hole in the field and will see different things. It's not an exact science*'. Because of this difference in balancing and negotiating many significant factors, no two advisers will give the same advice, something which is acknowledged by the advisory and farming community alike. These agronomists' comments describe the advisers' unique interpretation process:

A lot of farmers say with great glee 'you know they [advisers] never tell me the same thing' and they never will, you don't get two sets of guys the same. If you put two guys in the same field with the same problem they would come up with different answers (Independent agronomist DG).

We have to make a judgement on the day using the information available. We try and provide as much information as we can to make the decision as right as it can be but it might not necessarily be the right one, as other things come along (Independent agronomist N).

7.4.2 Farmers' interpretations and transformations of knowledge about soil best management practice

Advisers understand that they can only provide the advice, the decisions about using it remain with the farmer. As one independent agronomist (PT) said '*You can give them as many plans and guides as you like but no one's going to force them to do it, it's entirely up to them*'. Farmers' utilisation of advice is not straightforward, they accept, question, ignore, contest, compare, and transform advice, they also verify it by checking with other sources and occasionally complain of poor or inadequate advice. The extent to which farmers negotiate advice will depend on the relationship with their adviser as trust, adviser competence and impartiality are all factors that affect farmers' advice utilisation. With regard to how farmers evaluate the quality of the advice they can view this subjectively as well as in terms of financial returns, for example, one farmer (X) noted '*You get a warm feeling. If you're spending x amount per year and still having problems then you know it's no good. You know if you're getting good advice or bad*'. Farmers respond to advice, or utilise it, in very distinctive ways. Whilst some might accept it unquestioningly, others transform it, compare it with their own knowledge or reject it. The following discussion describes the conditions and adviser-farmer relationships in which these different responses occur.

The farmers that follow advice unquestioningly tend to defer to expert knowledge. For them agronomy is time consuming and an ever changing industry. They regard agronomists as providing a service, something that can be parcelled off to someone else. Part of this delegation is that farmers consider agronomists to be specialists in an area in which they are not so confident. As one farmer (MF) said '*He's [agronomist] the expert. I leave it to him*'. The following comments confirm this view:

The sector of farmers we deal with, they are deferring technical decision making to someone else. They are increasingly stretched doing more acres with less staff, they are much more involved on the farm than they were 20 years ago, they tend to delegate for chemical decisions, variety decisions and fertiliser to people like me (Distributor agronomist RW).

I'm a specialist at getting mucky behind cows, when it comes to crops I'm happy to use someone who knows the current thinking, they are the expert on that (Farmer AD).

There are other reasons for following advice. Some suggest that having paid for advice the farmer will be inclined to follow it, others consider that farmers use agronomists almost as an insurance as farmers have a lot of risks to accept and if they defer some to an agronomist, then if things do go 'pear shaped' the insurance will cover it. The culture of 'blame and claim' is quite established in agronomy with large numbers of claims made annually for failed products and yields. This might explain why some farmers follow advice even if they don't agree. One farmer (R) talking about a recommendation for fertiliser remarked '*He [the adviser] doesn't always get it right, we don't always agree. This year I didn't agree with his advice and crops suffered from it*'. In some cases farmers follow agronomists' advice simply because they just do not have the interest in agronomy, for example, one farmer (BB) explains '*It's not the part of farming I'm most interested in, it's where your priorities are*'. These adviser-farmer relationships in which the adviser is treated, and behaves, as the expert are typically characterised by a lack of consultation.

Many farmers, however, question or negotiate advice; they might do this for a number of reasons such as lack of respect for the adviser, confusion, contradiction, or conservatism. Farmers do not readily accept advice when they do not respect the competence of the adviser. Cultivation is an area where farmers would be least likely to take advice because they have little faith in agronomists' skills and experience in these practices. Agronomists recognise their limitations.

I'm an advisory agronomist, I'm not a practical farming manager, and when someone like me says 'look at all that soil wash what a terrible job you made of ploughing this', I can tell you in mid October, when they are flat out, they are likely to turn around to me and say 'well what do you know?' (Independent agronomist JC).

Sometimes lack of common understanding can explain farmers' reluctance to accept advisers' advice, this particularly relates to the economic pressures and the day-to-day risks of farming, as this farmer observes:

My agronomist is ex-ADAS and his thoughts on life are totally different to mine, he's never been under pressure. I say that with respect but if you work under farm management constraints you think a little bit differently. He thinks agronomy, I'm thinking gross margins (Farmer P).

Contradictory advice coming from different advisers and organisations, from other growers and the farming press can confuse farmers. The questionnaire results revealed numerous incidents of advisers contradicting each other as discussed earlier[63]. In these cases farmers can end up ignoring it completely and trusting their own judgement, as these remarks suggest:

There's always going to be some conflicting advice, you can't avoid that. A lot of information goes to people, they have to sort it out and judge it for themselves as to which way they go. I know some farmers will take advice from seven people and then do something completely different (ADAS adviser P).

[63] 38% distributor agronomists, 30% independent agronomists, 26% ADAS, 5% RDS advisers and 3% conservation advisers reported that they had had their advice contradicted.

At the moment if a farmer has two bits of information he'll have to make the decision himself. He might just say 'one person wants one thing and one wants the other; I'll ignore them both' (ESA Project Officer A).

One of the biggest sources of confusion can be where advisers' recommendations do not concur with the national farming press or with farming friends. Although referring to fungicide use, the following situation, where a farmer tried to resolve the difficulties of contradictory advice from his advisers and from his farming friends, demonstrates some of the subtle games that are played out when advice is given. It also reveals one adviser's strategy when in dealing with questioning of advice, and his perspectives on risk.

Farmers have always been very crafty about information although sometimes they do take it from wrong places. Even now the only questioning I get to my advice is where someone has been in the pub with his mates and his mates aren't doing the same as you are getting him to do. A classic at the moment is, I see a high risk with oil seed rape and Scleratinia and I think it's a matter of policy considering the amount of money you've spent that you should put a fungicide on, if you get the disease it's up to 90% yield loss. This guy, his mates say we're not doing ours this year we will save ourselves some money, so suddenly he thinks he's wrong. He first tries to get me to detract my advice, very clever, a mind game, so that he's got it both ways he's with his mates but he's also got me to back down, and that's a trick a younger adviser falls into, he gets talked around and says I suppose you're alright; so the farmers covered he's got your endorsement and he's not spending money. But I say 'no that's my recommendation'. I say 'If you want to gamble go to the casino and put some money on the black'. I never withdraw a recommendation, I leave it in writing there, if you wish to gamble it's your decision (Independent agronomist DG).

Confusion can also arise when the experts themselves do not agree on certain practices. Faced with different opinions, some farmers try to accommodate both and rationalise the information. One farmer (P), for example, described how two reduced tillage meetings he had attended run respectively by ADAS and by SMI had come to completely different conclusions. Whilst the SMI meeting expounded the overall benefits of reduced tillage, the ADAS presentation painted a different picture, where the cost savings were far outweighed by the impact on yield, as he explains '*I find the sort of topic that attracts enthusiasts you get two polarities and you have to have a mix of both and truth probably lies somewhere in the middle*'.

As well as accepting and questioning advice many farmers use advice but transform it. Like advisers, farmers modify advice for their own conditions, they might change the amount or timing of a fertiliser recommendation, perhaps follow some best management practice recommendations but two months later than the adviser intended, or be selective in the advice they take and the advice they ignore. Those better informed farmers will compare advice from farm advisers with recommendations from tools like RB209 and from local research institutes, and together with reference to their own knowledge will modify it accordingly. The reasons for changing advice include saving costs, simplification or when the advice does not conform with their own knowledge and experience or inclinations, for example, one farmer (MF) explained '*He [agronomist] would come to me with proposals which we discuss. If I thought they were right we would do them, if not I'd modify them to what I wanted to do*'. Farmers will also change advisers' recommendations according to the yield and profit that they want to achieve. This has implications for fertiliser targeting, for example, farmers consulted in the SUNDIAL-FRS project admitted that they added extra onto their advisers' N recommendations.

Sometimes, farmers are given a recommendation by their adviser and then add 10%, N is very cheap, often they make any profit on the last tonne or so of the yield, so it's very important they get that and not miss it for the expense of few pounds extra (Researcher Y).

Advisers suggest that farmers will change their recommendations to make life easier. They explain that the nutrient budgeting message had not got across because farmers tend to have very simple fertiliser management systems, even when they have decent soil analyses. Other advisers complained about farmers' 'laxness' in applying accurate fertiliser recommendations. The following advisers' comments demonstrate these views:

Farmers often partially override results to simplify them. For example, if you have a group of 6 fields away from the main holding perhaps 5-6 miles down the road, which is very common these days, it may be that soil indices for NPK would require perhaps 2-3 different N prescriptions. They'll often take a look at that and say 'I can't handle that' and instead go for a blanket approach (ESA Project Officer A).

They [farmers] think 'oh well, Cathy says 3 bags to the acre, we'll put 2 on because that's what we've got in the shed and balance up next time'. Farmers are very lax about N (Independent agronomist CH).

Lack of understanding and general competence or commitment is a further reason why some farmers do not follow recommendations. Some advisers view the farmer quite critically in this respect, describing them as '*lax*', as '*not having a clue*' about certain practices and not having the competence to handle new demanding soil best management practices. One farm management representative described his frustration when he was asked by a farmer to go through RB209 with him and provide recommendations for his farm. The adviser even went to the point of converting the figures to cwt/acre because the farmer was not using metric units. However, when he enquired how the farmer had got on, the farmer replied that he had found it a bit complicated saying '*I just mixed it all together and divided it by the area*'. The agronomist knew they were not seeing things in the same light and that the relationship would not work so terminated the contract, as he said '*that was the end of that, no point of him being miserable or me*'.

Farmers also tend to compare advice with their own knowledge and often give priority to this local knowledge and experience, as an independent agronomist (Q) said '*Some farmers have vast experience in soil management and are not receptive to new concepts*'. This can lead to transformations in advice to suit local circumstances such as weather or soils. Similarly farmers are reluctant to accept outputs from models or guides which are compiled from national data and do not concur with their own experience and observations, for example, one farmer (AB) remarked '*I prefer freehand anyway, there are so many factors like weather and soil that you make your own mind up and then run the model in parallel to see how they* *compare*'. Farmers also often believe their own experience and competence cannot be improved upon:

Farmers in general consider they know already how to manage their particular farm and soil. They are very loathe to change practice or consider any researcher/adviser can improve their own activity (Questionnaire respondent: distributor agronomist).

Resistance to advice is, however, also attributed to farmers' conservative nature. Although advisers recognise that farmers are all individual businesses they tend to view them as traditional, slow to change, preferring to stick to familiar systems and not taking risks, as one independent agronomist (DG) remarked '*They have farmed that way for years and don't like change and being told what they should be doing*'. Small traditional family farmers in particular are described as living with something for years and not appreciating that it is a problem, like slurry spreading on frosty days, they just keep on doing what they have always done.

Farmers are very sound traditional people and are reluctant to change unless something really stimulates them to do so because they are very conservative solid people (SMI board member adviser A).

Those with traditional manpower and equipment cannot afford to change, and often do not see the benefit of, for example, starting soil analysis or nutrient budgeting. They were also described as rejecting new ideas that contradict their own experience and observations, as demonstrated in the following agronomist's comment from the SUNDIAL-FRS case study.

I remember memorably actually running SUNDIAL for one of my clients and presenting him with results. He looked at them and said 'hmm I agree with this one and I agree with that one but I don't agree with this one'. I asked why and he said 'because it's too different from what we're doing now so I can't accept it' and I thought well that just about sums it up! (Independent agronomist CH).

Reduced tillage involves losing the tradition of ploughing and often farmers are reluctant to relinquish this tried and tested practice, as it is a system that is proven to work. Resistance can be strong and farmers prefer to change in moderation and refer to neighbours or other farmers who have launched into reduced tillage as 'radical'. Changing to best management practices often involves a change of outlook as much as anything, whether it is efficient fertiliser use, using nutrients in manure or reduced tillage. For example, for farmers to start viewing manure as a nutrient source will involve a whole new perspective and farmers appreciate this will be difficult:

From a practical sense most of the time our dirty water is a waste product to be disposed of rather than a fertiliser to made use of. It's probably going to take a little bit of time for us change our thinking on that (Farmer TG).

Reduced tillage enthusiasts also see the main constraint for farmers, like agronomists, as requiring a change in thinking. It was stressed that they have to change everything and develop a whole new out look. As one farmer (J) explained '*It's a change in attitude as much as anything else, not what we're used to, we farmers we don't like change!*' This risk aversion is reflected in a number of farmers who, although they were trying reduced tillage, kept their ploughs '*to fall back on*' or '*to keep their options open*' in case they were needed, as one (Farmer J) said '*It's always the weakest line is to give up go back to what is familiar to you[the plough]*'.

This cautiousness mirrors that displayed by some advisers interviewed in the SMI case study (Chapter 6). Farmers want to be assured of the benefits of a new system before adopting it wholesale. The word 'convinced' cropped up many times in interviews with farmers. To be convinced farmers need to talk to other growers, to see facts and figures, to observe the practices in operation and of course to practice it themselves. They are constantly looking for reasoned arguments to support any decision they make, as these comments demonstrate:

You just have to convince yourself, that's the difficulty. You know the system you have works but do you veer off into something so radically different? You get to Christmas and you're in a mess, you've lost everything, you're on the sort of land where you don't get a back up. It's a case where you have to do things in moderation (Farmer P).

A lot depends on the soil structure you're on, without a shadow of a doubt with the sort of soils here. I don't care what anyone says; I'd take a lot of convincing to go into a system where you didn't invert the soil for the benefit of the soil (Farmer M).

This section has demonstrated how, in the same way that advisers' utilisation of knowledge from research is not a simple process, farmers' utilisation of knowledge from advisers is characterised by negotiation, rejection and transformation. These processes, which inhibit integration of knowledge about soil, are often a function of the adviser-farmer relationships which lack consultation, respect and mutual understanding. The final section in this chapter goes on to examine how conditions more conducive to knowledge integration can be achieved and describes facilitative adviser-farmer relationships as potentially the most effective for achieving sustainable soil management.

7.5 Integration of knowledge about soil best management practice at the adviser-farmer interface: advisers facilitating change

7.5.1 Introduction

Section 7.4 described how lack of respect or understanding, contradiction and confusion often typical of expert adviser-farmer relationships, can lead farmers to ignore or change advice and as such do not provide appropriate conditions for the integration of advisers' and farmers knowledge about soil best management practice. This section demonstrates, however, that in contrast, a one to one facilitative farmer-adviser partnership built on dialogue, understanding, mutual respect and shared knowledge can provide the right context for knowledge integration. The elements of these facilitative relationships are described here in the context of soil best management practice. Consultation, rather than instruction, is a central component of facilitating farmers' decisions. Terms and phrases such as '*guiding*', '*steering*', '*help them try and sort it out*' were used by advisers to describe their strategies in this facilitative role. These advisers consider themselves as part of the overall process of supporting the farmers' decisions, as an independent agronomist (TB) said '*We see ourselves as helping to advise farmers as to the pros and cons in their farming* *systems*'. Working together and setting objectives is fundamental to this approach and some advisers and farmers describe their working relationship as a partnership in which the strategies and objectives are based on understanding the farmers own needs, as an agronomist explains:

Once the farmer sets the agenda, we then make a strategy. The skill is sitting down with farmers and finding out what he wants. Superficially they all say the same, more money, quality of life etc., but once you probe, you find they have an agenda which is a function of farm and family (Independent agronomist N).

Sharing knowledge, dialogue, explaining principles, talking the same language and shared understandings are all identified by this research as central to the integration of knowledge from advisers and farmers and provide the basis of facilitation. These processes are considered separately in the following analysis.

7.5.2 Processes that enable facilitation: sharing knowledge and taking joint decisions

Some advisers and farmers work closely together, they set objectives and field walk together and combine their knowledge and experience to arrive at a joint decision. Farmers might question the advisers' fertiliser recommendations and advisers value their input, often combining the farmer's knowledge with their own to compromise on a figure. For example, a farmer describes how this method was used to arrive at a figure for nitrogen rates:

We do it between us. He [the agronomist] comes up with a recommendation and it's usually on the lower side than I would put on. I'm in Morley as well and I get information from them. So yes, I do question him and he says 'go by my experience as well' (Farmer MF).

Agronomists are constantly interacting with farmers. They refer to farmers' knowledge, often incorporate it into their advice and in some cases even use it in preference to their own because they value its local relevance. Integration of knowledge by compromise and adjustment is common while in some cases a farmer's input may lead agronomists to question their own recommendations, as this comment suggests:

I might recommend a rate and the farmer's rates might be 20-30 kg higher so we come to compromise. If it was 50-60 kg higher then I think 'does he know more than I do through experience? Do I defer to his logic or do I defer to mine?' (Independent agronomist PT).

Agronomists appreciate working with farmers because, not only do they gain information from the interaction, but farmers benefit from an increased understanding of the processes involved and where farmers understand the process, for example, of calculating N rates, they become equitable partners. In this regard agronomists appreciate dealing with the more progressive farmers and the BASIS trained farmers. They find they are interacting more on an expert level and can adapt their message to the competence of the farmer; that they can work more closely with farmers and leave more tasks to them. The comments below show how farmer knowledge and experience are an undeniable resource for the adviser. This is supported by the questionnaire data (Table 5.1). Many freely admit that they learn most things from farmers or from conversations with farmers and emphasise the practical nature of the information.

... and they think they learn from me. I learn far more from them, but let's not tell them that! I think it's essential, as a researcher, to keep your hand in down on the ground. I find that contact essential I just ring the guy up and he tells me what I need to know (ADAS adviser C).

Thinking back, I was quite naïve about min-till, it made sense, leaving residues on the surface, protecting soil. It's a convincing idea until you actually start talking to farmers and experts on tillage techniques, then you realise this is not the way forward. And good farmers know this, they've gone through these cycles. So the whole thing comes tumbling down. This min-till thing is a beauty about not really understanding the problem (Environment Agency Representative A).

7.5.3 Processes that enable facilitation: dialogue

Dialogue through discussion between advisers and farmers is key to enable knowledge exchange, to establish what each of them knows, what they want to achieve and what are the constraints to this. Points of discussion can include overall strategy as well as the specifics such as detailed fertiliser applications. Some agronomists see the value of setting clear objectives with farmers against which they can measure success of achieving these as well as ensuring they identify what the farmer actually wants. Some agronomists interviewed take the view that farmers should almost write a statement of objectives for each field and ask themselves *'What are they trying to do? What are they trying to achieve?'* All advice can then be based on this. Advisers describe how, by coming to an understanding about objectives, this strengthens the relationship with the farmer and makes the advice much more effective. The dialogue between advisers and farmers often provides an outcome in itself.

You'll say to him 'look you want to achieve this' he'll say 'so how are you going to do that?' and I'll say 'so and so' and he'll say 'you can't do it like that you have to do it this way'. Immediately you have a rapport (Independent agronomist SD).

By soliciting a response from the farmer it immediately informs the adviser about the farmers' situation, as revealed in this example about contour ploughing.

It's a very nice way of talking it through because instead of it coming through as a recommendation 'plough across the field' you're able to say 'what would happen if you ploughed across the slope?' and they say 'you can't possibly do that on this field because of x, y and z ' and then I'd back off (Distributor agronomist TB).

Part of this dialogue compels advisers to listen and some advisers place a lot of importance on their own listening skills. Farmers value this listening, discussion, feedback and the simplicity of the adviser's language and explanation, as well as the social contact, as an independent agronomist (DG) remarked '*Yes they'd [farmers] far rather sit around a table and talk to you for half an hour than sit down and read for 5 minutes with this literature*'. Failure of the Environment Agency to engage farmers in the Landcare catchment was put down to a reliance on publications and lack of such one to one personal interaction, as a farmer explained:

I think they [Environment Agency] have got to get out on farms more, put themselves about a bit more, literature through the door is good to certain extent but there has to be a personal touch eventually you need to get your point across on both sides on a personal basis (Farmer AD).

7.5.4 Processes that enable facilitation: explaining principles

Many advisers regard themselves as facilitators, helping farmers to understand the problems and their own systems. For example, an independent agronomist (TL) commented *'Soil wash. It's insidious light fine stuff that's goes off and you don't really see it, but it's getting them [farmers] to <u>understand</u> it's coming from somewhere and it's having an impact'*. The terms 'educate', 'teach and 'lesson' are used a lot by all advisers not necessarily in a patronising sense but in terms of raising general awareness about problems as well as teaching certain principles and practices as a way of empowering farmers to undertake their own decisions. Advisers see that explaining problems to farmers in terms he can understand is an essential basis of advice. This is believed to be the basis of the MANNER PC tool, as one ADAS adviser observes.

For MANNER everything is logical, if you get more rain you get more leaching; thicker slurry, more ammonia goes off. You teach them those as part of understanding of what MANNER does. Teach them the basis rules (ADAS adviser C).

In the same way advisers prefer to explain the principles of soil management and cultivations, rather than give specific advice as this is a complex issue and a lot has to do with making timely decisions related to soil moisture conditions.

It's a matter of educating these guys to have a spade on tractor, to see what they are actually doing rather than just charging on down the fields. What you think you're doing rather than what you are doing (Independent agronomist P).

7.5.5 Processes that enable facilitation: finding common ground

Advisers stress that achieving common ground through sharing the same language and reference points allows them to engage the farmer and set the scene for more effective recommendations to be made which the farmers can practically use. The need for anyone promoting best management practice to communicate effectively with farmers by *'putting the message across in a language farmers can empathise with'* as one ADAS adviser (B) said, is emphasised by many advisers. One means of finding common ground is to ensure advisers and farmers use compatible units of measurement. The importance of simplifying fertiliser recommendations and using units familiar to farmers was highlighted, as it is thought that farmers resist anything too complicated.

Farmers immediately say 'I can't do that, you've got to simplify that'. You'll always be up against that one. We always tend to look at anything that isn't very simple and try and simplify it. I use MANNER and FERTIPLAN a lot and work that into a very simple application recommendation for clients based on kilos of product because that's what they want to know 'How many kilos of 0:20:30 should I put on this field?'. The recommendation will say 5 bags of 0:20:30 applied to field x, it won't say 75kg of phosphate, 120kg of potash. They haven't got as far as kilos of NPK, they're interested in the commodity (ESA Project Officer A).

Using a financial reference by appealing to the farmers' pocket is recognised by many advisers as another important way for advisers to engage them. There is a common belief among advisers that once soil management is explained in terms of costs the farmers will respond more positively, as these remarks suggest:

If you don't start from the point of finances, our experience is it goes wrong very quickly, because they [farmers] are risk adverse in terms of changing behaviour, if in any way it puts their returns at risk (Distributor agronomist P).

The biggest thing to get around [communicating soil erosion issues to farmers] is why let your principle asset wash away. If you explain it to them that way, they seem to want to start taking measures (Independent agronomist BH).

A FWAG adviser (A) explained to farmers that spreading slurry on a frosty day was uneconomic practice because by the time the growing season came, every scrap of N will have been lost to the atmosphere or leached out, as he said '*I think once you explain to them that's there's a cost to the business, they will sort it out*'. Similarly persuading farmers to use the nutrient value of manures can be done in financial terms, as this consultant's comment shows.

Certainly as far as FYM is concerned it's always been a nuisance. If you sit down and explain to them that each cow produced £35/ha fertiliser year, which you save on your fertiliser bill. They are now in a loss making situation, £35/ha is a lot of money, so they are starting to think about it (Consultant TL).

Advisers develop other ways of using terms and references that farmers understand, for example, they often point to smell as a sign to farmers that they are loosing nutrients from manure, for example, one independent agronomist CH) said '*I say to them' if you can smell it you're loosing nutrients*'', or where visual evidence of pollution is missing, for instance an ADAS adviser (C) explained '*If nitrate goes in the river it's invisible, but odour he [the farmer] can understand why the village is giving him grief*'.

7.5.6 Processes that enable facilitation: shared understandings

A number of advisers, particularly agronomists, see themselves as having an intimate understanding of farmers' practices because they are constantly on farm. They believe they share the same views as farmers in terms of economic decisions and the level of unavoidability in some practices. Farmers value this characteristic, as one farmer (B) said '*My agronomist looks at reduced tillage in same light as me, if you save £20/acre in cultivation and lose a tonne/acre in yield then what have you saved?*'. Sharing the same outlook is seen as vital in understanding soil problems and addressing the issues, but is something initiatives have often failed to do; a Environment Agency representative (B) said '*If you don't understand the soils and crops from the farmers perspective you'll never bring them on side because they see it as being impractical. We keep falling into this trap each time*'. Agronomists' sympathies typically lie with the farming community and some align themselves with farmers against those regulating or telling farmers what to do. They see the farming community as willing to do best management practice but constrained by costs, either the real capital costs, for example, of building a slurry store or the perceived loss of profit. Some agronomists emphasise that farmers are farming to make a living and have to safeguard their margins and that this justifies any practices which breaks the Soil Code, the decision ultimately is an economic one, as these comments reveal:

Time and again they like to do something but can't afford to start. It's a frustration because farming is a largely big commercial operation where everybody is doing it on the bottom line not to be good guys (Independent agronomist DG).

They are trying to make a living. They don't willingly abuse their soils. Economic pressure might force them to undertake undesirable practices such as cropping steep fields. (Questionnaire comment: independent agronomist).

As well as economic constraints agronomists emphasised practical constraints which limit farmers' options for changing their practices. The weather is seen as major factor beyond the control of farmers, making many practices untimely and the resulting degradation unavoidable, as the following agronomists' comments demonstrate:

Every single one of them would very happily do what he could to help the environment and not pollute streams and not dump muck into water, but they are constrained by weather conditions (Independent agronomist DL).

On a number of occasions a farmer will know that he may be damaging his soil etc. but he may not have any option if he is to get the crop drilled at all. The last two Autumns have been a nightmare on heavy land (Independent agronomist PS).

Advisers empathise with the difficulties of disposing of farm waste and often regard spreading farm waste in wet weather as unavoidable if storage facilities cannot cope. The same sense of unavoidability was expressed by farmers and advisers alike, even to the point of using the same words (underlined for emphasis by the author).

This chap ended up putting parlour washings on extremely wet sloping land. What else could the fellow do? Nothing, he was polluting the stream, there no doubt about it, but there <u>was nothing he could have done</u> (Independent agronomist TB).

I've seen water run of from <u>my</u> fields and it's brown flowing straight into the river. <u>Nothing could be done about it,</u> we're on free draining land if it's washing off here it's washing off everywhere. Nobody likes to see it from a financial point of view, it was no great quantity of soil but you know very well the nitrates are going out with it (Farmer P).

This section has highlighted the importance of consultation, explanation, mutual understanding and dialogue rather than expert instruction. These processes which underpin facilitative adviser-farmer relationships, enable the integration of knowledge from advisers and farmers.

7.6 Chapter summary

Results presented in this chapter show that advisers, in terms of soil best management practice, can be potentially very influential. However, many experience conflicts between the expectations of their clients and those of the soil best management practice community particularly agronomists, and need to negotiate different pathways to reconcile tensions between research and practice. It is clear that adviser knowledge interactions with farmers are far more complex than a simple notion of knowledge transfer, that is, advisers relaying knowledge generated by the research and policy community to farmers, and farmers using it unquestioningly. Instead knowledge processes at the interface with farmers are characterised by influence, tension, conflict, individual interpretations, negotiations and transformation. However, where respect and mutual understanding and dialogue underpin the farmer-adviser relationship knowledge integration, rather than rejection or transformation, is more likely. The discussion in Chapter 8 examines in more detail how facilitation through integration can be achieved.

Chapter 8

DISCUSSION AND CONCLUSIONS: THE NEED FOR KNOWLEDGE INTEGRATION AT ADVISER INTERFACES WITH RESEARCH AND PRACTICE

8.1 Introduction

Chapter 8 provides further discussion of the results of this research, draws some conclusions and makes suggestions for policy and future research. A key finding of this research has been that the acquisition, generation, utilisation and integration of knowledge about soil best management practice lie in the processes by which advisers, as social actors, interact with, negotiate and accommodate others' life worlds. Of these knowledge processes, knowledge integration has emerged as central to the effective exchange of knowledge at both the adviser-researcher and adviser-farmer interfaces.

Knowledge integration is the continuous process which involves the synthesis and assimilation of knowledge from different sources. The results have shown that it is also intimately linked to acquisition, generation, utilisation, transformation and recreation of knowledge, and as such constitutes the most significant process. Although integration is carried out by all AKIS actors, it is the advisers' integration of knowledge which is most significant as they endeavour to synthesise and assimilate knowledge generated from both the research community, as shown in the case studies reported in Chapters 5 and 6, and from the farming community, as shown in Chapter 7, with their own knowledge. Given that knowledge processes have been shown to be social processes, any discussion of integration must be undertaken in the context of advisers' social interactions. As such this chapter first examines the nature of the advisers' social interfaces and in doing so provides the context for a discussion of integration at the interface with research and practice, exploring the conditions that enable and constrain this key process.

8.2 Advisers' social interface: the context of integration

Previous research concerned with the role of the farm adviser has described them variously as disseminators or change agents (Rogers 1995), field level bureaucrats delivering policy in agri-environment schemes (Cooper 1999; Juntti and Potter 2002), mediators between the land manager and multiple sources of information and expertise (Garforth et al. 2003), purveyors of expert knowledge (Burgess et al. 2000) or representatives of commercial organisations (Hawkins 1991; Lyon 1996). These studies have aligned the advisers with the interests of their institutions as mediators for policy, research or commerce.

Other research emphasises the conflicts that advisers are exposed to mostly in interventionist institutions where they are charged with introducing new initiatives (Long 1989) and reference has been made to the two way interaction the role demands (Rogers 1995). The way that advisers find themselves in an arena of conflict has been identified, where they have to negotiate different agendas, bridge different cultures or life worlds, and as Rogers (1995: 336) puts it 'have to breach the social and technical chasms' between different actors and their institutions. These studies, although they recognise the different worlds that the advisers interact with, tend to focus on the differences and conflicts and have not fully explored the extent to which advisers align themselves with the interests of the different communities with whom they interact.

In contrast to previous research which regarded advisers as technical experts or implementers aligned professionally with research and policy organisations, this research has revealed that in the context of soil best management practice, many advisers, notably agronomists, in fact exist and operate within the practical world of the farmer. Rather than having to have 'one foot in each of two worlds' (Rogers 1995: 336) advisers in many cases have both feet firmly placed in the farmers' world.

The failure to appreciate this perspective in previous studies in the UK can be attributed to their focus on policy implementation situations where advisers face a very different set of conditions[64]. Unlike agri-environment schemes, soil management practices are an integral part of farm practice and changing them can have an impact on the whole farming system and farm business, not just one element of it. Because of this risk to profits are involved and failure can have financial consequences both for the farmer and for the adviser. Given that previous studies can only partially inform a discussion of the results of this research, the new perspectives proposed in Chapter 3 are needed to understand advisers with respect to the knowledge processes associated with soil best management practice.

It is clear from this research that some advisers and farmers interact in a context of shared experiences and understandings, with this being the case most notably for agronomists. They share the same expectations as farmers, the same priorities, concerns, understandings of practical farming constraints, the same unavoidability of certain practices and even the same language to defend poor practice, as described in Chapter 7. These 'interlocking intentionalities' as Long (1989: 237) calls them, are a characteristic of social interface linkage and occur where actors' life worlds overlap, that is when they become oriented to the same goals, share a common commitment to rules or values (Turner 1974: 17) and a common set of experiences (Waldenstrom 2002). Although they exist in different institutional contexts, the way that advisers and farmers make sense of events according to the rules, norms and values of their group are similar (Shotter 1993; Tsouvalis et al. 2000b). Agronomists in particular share the same context as farmers in terms of financial constraints on their farming decisions. In effect the knowledge processes they engage in are situated in the same cultural, economic, agroecological and socio-political context. This paints a very different picture to the traditional view of the adviser as a technical expert relaying messages on behalf of the scientific/technical or policy community.

Conversely the advisers and researchers investigated in this research demonstrate different outlooks, appear to operate in very different contexts and to inhabit separate

[64] As detailed in Chapter 2, soil best management practices are non-prescriptive, technically challenging and perceived as high risk, demanding expertise and experience from both farmer and adviser. Advisers concerned with best management practice cannot provide financial incentives and compensations, they are not in position of authority but instead must respond to farmers' demands. Advisers concerned with best management practice for soil are diverse and few receive support for these practices from their respective organisations compared to a relatively homogenous agri-environment scheme community backed up with a strong administration.

life worlds. They refer to different reference points to inform them, the researcher to verifiable research methods and the adviser to observation and experience, and whilst advisers were described as empathetic to the farmers' situation, many researchers were considered as lacking any understanding of practical farming. This distinction provides the backdrop for a discussion of knowledge processes and integration in particular, since the results have revealed that where actors share experiences, expectations, norms and values, knowledge integration about soil best management practice is more effective.

It is not the intention to categorise all advisers as having strong allegiances with farmers nor all researchers as lacking in understanding of farming practicalities as clearly they do not act as discrete homogeneous groups. Some advisers for instance exhibit strong allegiances towards the research community, regard it as essential to underpinning their activities, and have great respect for the researchers. These same advisers can be dismissive of farmers' behaviour and expectations. In the same way, some researchers do exhibit a greater understanding of, and dialogue with, the farming community. Clearly a spectrum of cultural behaviour exists, but the social interface perspective does provide a useful device for understanding the context of the knowledge processes in which the majority of advisers, principally agronomists, interviewed and observed in this study engage.

Few researchers have explored advisers' cultures or allegiances and the associated roles they play. Some commentators have alluded to the different roles and demands of extension agents and consultants. For example, Gasson and Hill (1996) distinguished different extension and consultancy sub systems in the AKS, arguing that they carry out different tasks and approach their role differently, the former taking the results of research and processing them into messages, the latter translating extension messages into individual advice. Others have described the transformation in approach and overall culture of operating demanded when ADAS advisers became consultants following privatisation (Bell 1998; Rolls 1998). Some have provided more in depth insights into how advisers demonstrate a greater understanding of, and sympathy towards, the practical farming challenges associated with agri-environment scheme implementation or pollution control (Lowe et al. 1994; Juntti and Potter 2000). These studies, although they hint at an alliance between the farmers and advisers, only provide a limited view of the advisers' world in the context of soil best management practice. This discussion of advisers' integration of knowledge will be placed in the context of their social interfaces, providing greater insights into the social nature of the knowledge processes they engage in.

8.3 Knowledge integration

The advisers' integration of knowledge both from the research and farming communities has been shown to be central to the facilitation of soil best management practice in this research. Although reference has been made to advisers' assimilation of knowledge both from research and farmers (Papy 1994; Portela 1994) there has been little exploration of the elements and strategies involved. Previous researchers have focused on integration as a prerequisite for an effective knowledge system or network (McDermott 1987; Kaimowitz 1990; Roling 1990; Winter 1995; van Crowder and Anderson 1997). In this respect the term integration refers to the coherence of the system achieved through strong linkage mechanisms. However, the research reported herein has revealed that such mechanisms do not always guarantee effective linkage. Instead it is the social processes of working to the same reference points and shared understandings through dialogue that can achieve true integration of knowledge.

In an attempt to understand such integration of knowledge more thoroughly some commentators have suggested that the merging, blending or integrating of knowledges from local and scientific sources is needed to achieve sustainable agriculture (Arce and Long 1992; Murdoch and Clark 1994; Clarke and Murdoch 1997; Morgan and Murdoch 2000). This view, however, emphasises knowledge forms rather than process and neglects the crucial social elements, which enable integration to occur most effectively. The following discussion provides insights into integration as a process embedded in social interaction.

8.4 Integrating knowledge at the adviser-researcher interface

8.4.1 Operating in different frameworks

Advisers construct and attribute meaning to knowledge from research in a very individual way, which is determined by their own experiences, objectives, influences and perspectives. This means that at the interface between science and practice, advisers' integration of knowledge is a complex process. Advisers receipt of soil best management practice research outputs is not uncommitted; rather than simple transfer and assimilation, negotiation, contestation and transformation determine what and how knowledge derived from the research community is incorporated into their advice.

The SUNDIAL-FRS and SMI case study results in Chapters 5 and 6 demonstrated that most advisers operate in a context of different understandings, interpretations and experiences from researchers, in effect they inhabit different life worlds. Whilst advisers are immersed in the practical farming culture and its context of weather constraints and economic imperatives, the researchers' world consists of abiding by verifiable scientific methods, bidding for money and meeting contract deadlines, publishing articles and where necessary providing dissemination to meet policy requirements.

The gulf between science and practice described by many advisers is testament to the different frameworks in which advisers and researchers operate. Advisers attribute this to researchers' lack of understanding and failure to appreciate the practical and economic constraints farmers operate under and the unavoidability of certain soil degrading practices. This was particularly highlighted for the soil best management practice options of fertiliser targeting and manure management, as promoted within the Landcare catchment to reduce diffuse pollution and for the SUNDIAL-FRS study where researchers' assumptions concerning the practical farming world were misplaced due to a fundamental lack of understanding.

Such dissonance was particularly evident in the way that some advisers take a different perspective to researchers concerning the validity of research methods.

Case study results suggest that advisers use different reference points and different rules to researchers when thinking about agriculture, and in this respect are the same as farmers (Molnar et al. 1992; Scoones and Thompson 1994; Engel 1997). Whilst researchers have the luxury to run experiments in controlled environments, for example, in SMI, advisers, like their client farmers, are embedded in a socio-economic context with ever changing conditions to which they must adjust and therefore reject plot results. Rejection of experimental plot data reveals that advisers often see science as irrelevant. This is consistent with debates about the validity of local and scientific knowledge where science is criticised as often partial, temporally contingent, conflicting and uncertain (Morgan and Murdoch 2000). In the same way some agronomists also dismiss DSS like SUNDIAL-FRS regarding them, at best, as no more than a tool and, at worst, a research spin off based on flawed assumptions about how the 'real world' of farming operates.

In contrast, researchers in SUNDIAL-FRS and SMI studies demonstrated a conviction in using research tools such as models and experimental plot data and a reluctance to recognise or incorporate other sources of knowledge. For example, in SMI some researchers rejected what they saw as invalid anecdotal evidence and observations from the practical community while in SUNDIAL-FRS researchers were unable to incorporate suggestions from the practical community because they did not 'fit in' to the model. Each group, advisers and researchers, were clearly operating according to their own norms and values. The researchers were unaware that these had implications for the efficacy of their research outputs, as, for example, in the SUNDIAL-FRS study where they expressed surprise that the model had certain limitations. This concurs with Wynne's (1996:118) comment that 'science communication is often ignorant of its own tacit 'body languages of institutional interests'. For the researchers, replication and comparison count, for the advisers and farmers 'fitting in available resources or changing circumstances to make it through the season' is important, employing, as Blackmore (2002) described it, a 'coping strategy'.

Because of these differences, advisers often regard research as ineffective, impractical and off target or partial with a hidden agenda. They are reluctant to implement the research outputs unless they can be demonstrated to be effective, practical and profitable. One of the main reasons for this dissonance is the lack of dialogue between the research and adviser community and lack of opportunity for mutual learning. The SUNDIAL-FRS did, however, show promising signs of dialogue where researchers tried to understand through consultation the *'reality of what it's like on farm'*. Similarly SMI researchers responded to criticism about data derived from experimental plots. Chapter 5, however, exposed few opportunities for researchers to consult advisers, advisers to feedback practical outcomes of research or contribute to setting research priorities within the AKIS.

These results concur with views of other commentators who argue that it is a false assumption that knowledge generated from science can be integrated or blended seamlessly into farmers' practices due to the manifold and diverse nature of knowledge held by both (Scoones and Thompson 1994). In the same way integrating knowledge from science with that from advisers is hampered not so much by the nature or form of knowledge but by the context in which it is produced.

8.4.2 Generation and utilisation of knowledge

The way advisers integrate knowledge generated from other sources is intimately linked to the way they generate their own knowledge. This generation is also an intrinsic part of their life world and provides further clues to their reluctance or inability to fully embrace and assimilate research outputs. Advisers generate their own knowledge, which they refer to and rely on to a greater degree than other sources. This knowledge, which is derived through experience and practice in particular localities, is highly valued by advisers and appears to be the main benchmark against which they refer all decisions. Advisers describe this knowledge as *'practical experience'* or *'user knowledge'*, and it has an intuitive element or *'a gut feel'* to it.

This knowledge is not acquired through any particular formal learning process but is learnt through practice, observation and other sensual methods, like feel and touch, as one adviser noted how *'to actually walk on that soil and feel it and see how spongy it was..'* made a big impression. Advisers use and generation of knowledge through practical or 'user' experience is consistent with the view of knowing as synonymous with doing, as held by Engel (1997) and of the notion of experiential knowledge conceptualised by Kolb (1984). It also accords with what Engel (1997:132) calls 'learning in practice' which he suggests is a more appropriate term than utilisation to describe the knowledge processes in which advisers engage on a daily basis. In this way what advisers know and how they go about learning is intrinsically woven into their lives as social beings. Such knowledge cannot be separated from the practices of its 'bearer'. As such it is instinctive in the every day practice of the adviser and is reflected in the way agronomists refer to it, for example, '*I live and breathe N recommendations intuitively*' or '*we're living with it all the time*' and the terms they use to describe it such as 'gut feel'. This 'knowing from within' is what Shotter (1993) referred to as knowledge characterised by practical understanding or as Bourdieu (1985) calls it 'a feeling for the game' (quoted in Tsouvalis et al. 2000b: 912). This is linked to everyday practical undertakings that are embodied in, and are an integral part of, the actors' resources, stock of knowledge and behaviour and as such strongly related to the notion of culture. Although previous commentators have noted that advisers' own patterns of advice in daily practice can vary, for example, Juntti and Potter (2002) called this the advisers' *modus operandi*, the intrinsic relationships between knowledge and action have been little explored.

In many ways this experiential knowledge resembles the local or tacit knowledge that some commentators ascribe to farmers (Richards 1985). Indeed such knowledge, which is constituted from a 'mixture of intuitive wisdom of experienced practitioners', is thought to be more suited to complex and 'ecosystem-sensitive' sustainable practices (Norgaard 1984; Roling and Jiggins 1994). Whatever it is labelled it is certainly derived in a very different context to researchers' experiential plots and trials. Advisers could therefore equally be described as having their own 'tacit body language' which is just as impenetrable to researchers as their knowledge is sometimes to advisers. Personal interaction in a context of shared experiences is thought to be the only way to communicate this locally derived tacit knowledge (Hassanein and Kloppenburg 1995). Opportunities for such personal communication between researchers and advisers are relatively rare as this research has demonstrated in the context of soil best management practice.

The way that advisers generate knowledge has implications for the integration of knowledge. Firstly the reliance and value advisers place on their own experiential knowledge, which they guard jealously and see as irreplaceable, can explain their reluctance to accept research outputs. Comments like '*real world experience is more important than most models yet developed*' or '*40 years of handling soil is invaluable*' demonstrate this. Secondly it means that integrating knowledge from science, which has been generated in a very different context, is problematic. Whilst advisers' intuitive knowledge prepares them for the familiar, advisers, like farmers, flounder when new situations occur. For example, using N fertiliser targeting and nutrients in manure are seen as particularly challenging practices for advisers, as comments like '*we're scratching our heads*' and '*who does understand manure?*' demonstrate. Advisers use their experience and intuition in such practices but these are challenged with the high fertility systems when manure is added, as one said '*local knowledge and experience help you with normality*' but in high fertility situations they become '*unstuck and struggle*'. This highlights the fact that advisers face as equally a difficult task as farmers in accommodating and integrating new, technically demanding best management practice (Tebrugge and Bohrnsen 2001; Coughenour 2003). Thirdly, lack of opportunity to generate their own knowledge through hands-on experience, notably in cultivations which is the farmers' domain, has led to advisers being unqualified to advise on certain practices crucial to soil management.

8.4.3 Advisers' integration and transformation of knowledge across the science-practice interface

In deriving on-farm recommendations, advisers endeavour to integrate knowledge generated by experience with that from formal sources. However, because of the different ways that advisers and researchers generate knowledge, and because of the dissonance in their life worlds, this integration is inevitably associated with transformation and negotiation.

Evidence gathered here demonstrates how advisers use tools, guides and training inputs to a large extent, however, in using these outputs for on-farm recommendations, advisers always refer to their own locally generated knowledge as a benchmark. Any technical input such as from a DSS or fertiliser recommendation tool are therefore used as a guideline and then modified through integration with locally derived knowledge, as one agronomist said *'it's a case of using that as an indicator then using gut instinct and historical knowledge to tweak that and make into a recommendation'*. This tweaking inevitably involves compromises, judgements and rejection of some knowledge, formal or otherwise. The process consists of incorporating existing knowledge and absorbing new information through validation, reflection and verification, as Long and Villarreal (1994) and Portela (1994) described, where new information and its sources are judged as acceptable/useful or are contested. At the same time feedback, inference, perception, reification, attribution and reality testing, as described by Roling and Engel (1991) contribute to these processes. In this sense it is a continuous and iterative process of evaluation, as shown in Figure 8.1.

Through these processes advisers develop competence and skills, as comments like *'I pick it up as I go along'* or *'it's a seat of the pants job'* demonstrate. In effect they are 'learning in practice' and generating new experiential knowledge as they go. In this sense advisers' knowledge is constructive in that it results in a great number of decisions and selective incorporations of previous ideas, beliefs and images, as well as technical elements. This is consistent with Engel's (1997: 127) observation that 'what is commonly held to be a process of knowledge transfer might be better understood as a continuous process of step-wise integration of knowledge, information, ideas and experience taking place by means of temporary task-oriented interactions between social actors'.

Integration is intimately linked to the transformation of knowledge generated by research. This includes a range of processes from the technical transformation of information into practice and knowledge through a series of evaluations and adaptations or as Blum (1991:322) describes it 'integrating into the original information further results of experimentation and experience by a series of people'. Transformation can occur through simplification, selection, changing the units of measurement or adding or removing a safety net. Advisers transform or *'calibrate'* using their *'own intuitive recommendations'* and *'play about with different scenarios'* using professional judgement informed by objectives, experience and observation before adjusting their advice accordingly. They constantly compare outputs from research such as guides or models with their experiential knowledge, and ask whether they are '*comfortable*' with the results or if they are what they would expect and modify them accordingly. Leeuwis (2000) considers that this interception, interpretation and refinement at a local level by farmers and, as has been shown here for advisers, can be thought of as a process during which new knowledge is created, as shown in Figure 8.1.

Although it has long been recognised that technologies and associated knowledge are modified by farmers through experimenting and adapting and ultimately reinventing practices as they are incorporated into production systems (Rogers 1983; Ramkumar and Rolls 1995; Garforth and Usher 1997; Coughenour 2003), few have considered that advisers also interpret, evaluate and reformulate the knowledge associated with practices. Transformative knowledge processes at the interface with farmers are an outcome of the advisers' individual interpretations and the context of advice provision. Their judgements, interpretations and compromises often lead individual advisers to formulate very different modes of advice for the same problem, as one farmer said of different advisers '*you know they never tell me the same thing*'. Thus as Arce and Long (1992) point out the knowledge that develops is not an accumulation of the facts but involves ways of constructing the world.

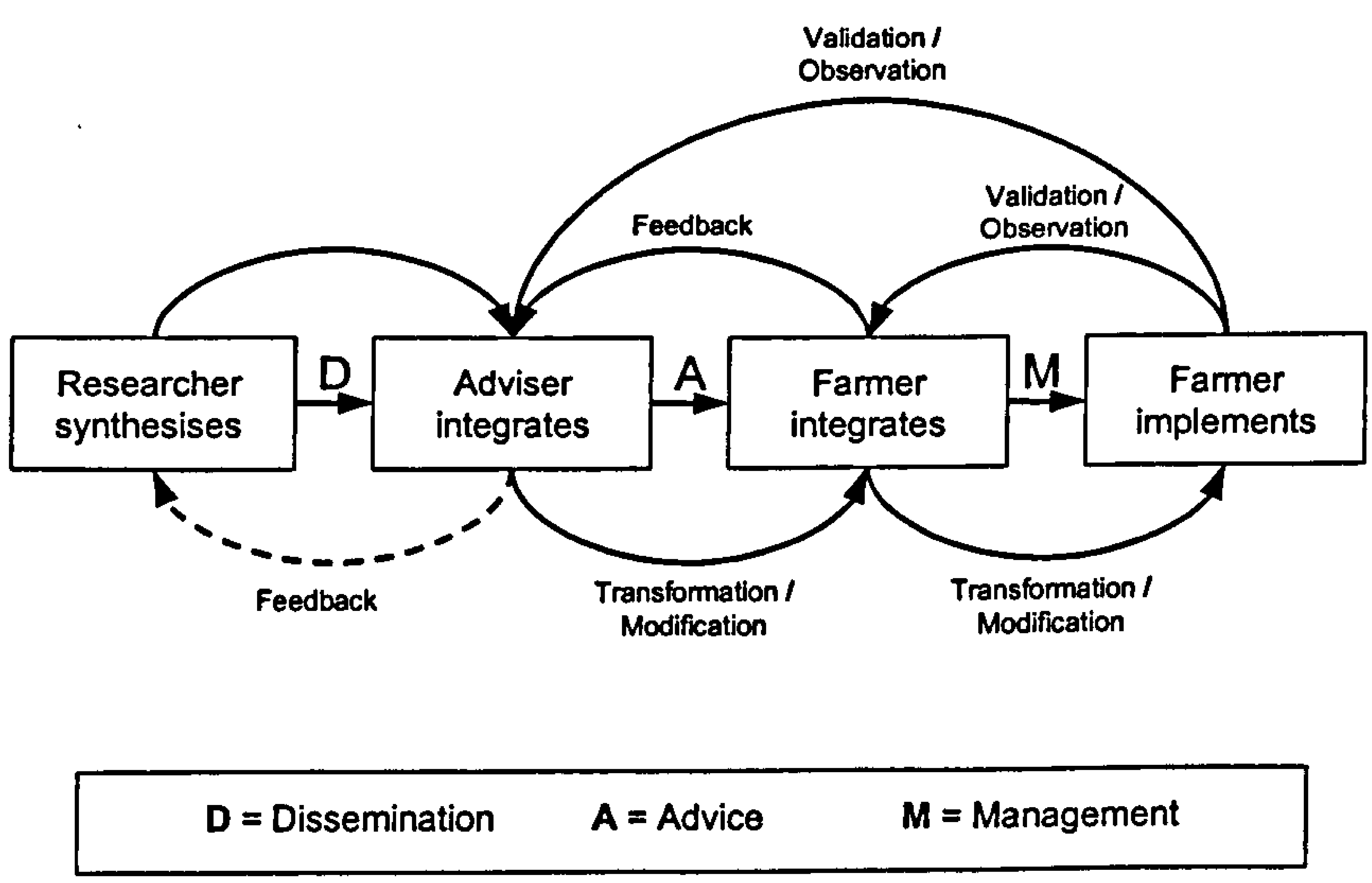


Figure 8.1 Integration, transformation and re-creation of knowledge across adviser interfaces.

Although previous studies of agri-environment schemes in England have shown that advisers play an interpretative role in terms of how they administer and implement schemes as they bring their individual assumptions, interpretations and agendas to the delivery of advice (Cooper 1999; Juntti and Potter 2002), these fail to consider the complex knowledge processes in which they engage. Juntti and Potter's (2002) description of agri-environment advisers as behaving in a similar fashion forming a 'cultural sieve' between policy makers and target groups and selectively controlling what reaches the farmer does provide some insights, however, in the case of the advisers in this study the extent of interpretation is far greater for three reasons.

First, the relative novelty of soil best management practice and its non-prescriptive and highly technical nature means it is subject to a number of interpretations and negotiations. This is particularly the case with soil best management practice where, as Ward and Munton (1992) found for pollution regulation, the rules are not fixed and the practice is still open to negotiation. Second, these interpretations are compounded by a heterogeneous adviser community, each bringing a diverse set of skills and experience to the process. Third, compared to agri-environmental advisers, some farm advisers like agronomists display wide autonomous professional judgment and adaptability.

This discussion shows that the processes of generation, transformation and integration that advisers engage in are all interrelated and continuous. It also reveals that knowledge is not a commodity to be acquired and transferred but a property of the individual adviser, enabling them to make inferences from experience, observation and reasoning. Individual advisers, using Long's (1989:50) words, 'categorise, code, process or impute meaning to their experience' in very different ways. External factors become internalised and come to mean different things to different people, so the advice that advisers provide becomes a socially constructed and negotiated process. As Garforth et al. (2003: 326) referring to Roling (1988) note 'at the level of the individual land manager...knowledge is not acquired by a simple 'transfer' from one person to another, but through a process of learning, internalisation and integration with existing knowledge'.

8.5 Integrating knowledge at the adviser-farmer interface

This research has clearly demonstrated how advisers are closely aligned to farmers in terms of shared expectations and experiences. Many also have greater opportunities for dialogue through one to one or one to group interactions than is the case for other AKS actors. It has been argued above that these characteristics will act to enable more effective knowledge integration at the adviser-farmer interface. However, the context of the delivery and the manner in which knowledge is communicated will also affect how knowledge is integrated. Tensions can result as advisers and farmers are increasingly being asked to respond to new demands such as policy initiatives, markets and regulations and they will respond in different ways depending on their goals and values. This means that in terms of achieving sustainable soil management advisers and farmers' expectations might not always coincide.

8.5.1 Economic imperatives, conflict and the balance of power

In the relationship between farmers and advisers, factors such as trust, power, coercion and tension determine what knowledge is transmitted and how. Knowledge generation, utilisation and integration have been shown to involve aspects of control, authority and power embedded in social relationships, with inevitable dissonances between different categories of actors involved in these processes.

All advisers experience some tensions between the expectations of the policy and research communities and those of farmers. Agronomists, in that they are paid to provide a service to client farmers appear to encounter the biggest conflicts. Ultimately their priority is to sustain their clients' farm business and they are reluctant to recommend any practices that they perceive might compromise the farmers' profit and at the same time their credibility. Risk of failure and being blamed are prominent concerns and in this context many question the 'win-win' best management practice messages being promoted.

Credibility is a critical factor in retaining clients and determines what and how advice is provided. Credibility is inevitably linked with risk and advisers tend to develop risk adverse strategies to avoid failures on farm. For many agronomists, who have no interest or concerns about soil management, this is not an issue. However, for those who consider best management practice and sustainable soil management as important, they are constrained as commercial decisions often have to take precedence over best management practice. These tensions reflect the wider debates about sustainable soil management discussed in Chapter 2 where conflicts between soil productivity and other soil functions were discussed. However, whilst some advisers are risk adverse, others are beginning to put a value on soil best management practice, recognising that a win-win situation is a possibility and that by staying abreast with developments they can remain credible and therefore competitive within the agronomy industry.

How different agronomists reconcile these conflicting objectives and determine priorities about soil is a function of credibility, risk, maintaining loyal relationships, retaining clients and ultimately their power relationship with the farmer. Each adviser-farmer relationship is different, while some advisers do not mind being rude to their clients and chastising them for instances of poor practice, others, in contrast, would not mention soil erosion even if it was obvious out of fear that it would upset the farmer and compromise their business relationship. Others see no conflicts and consider best management practice for soil and profitable farming as compatible, a 'win-win' situation; while others have purely a financial interest and might urge farmers to undertake tasks which might actually precipitate soil degradation like untimely tillage or creating fine seed beds.

At the adviser-farmer interface the balance of power dictates how and what knowledge is exchanged and integrated. Traditionally researcher-adviser-farmer exchanges take place in relationships of superiority and power with better trained researchers at the top above advisers who themselves are above farmers (van Crowder and Anderson 1997). This model no longer stands as it is now recognised that all actors have the power to contest or reject research outputs or advice, a function of a more fluid and fragmented AKIS in which many advisers must strive to answer the information needs of the user (Garforth et. al 2003). Although for most advisers (the exception being the independents) the power of decision making for goals and provision of resources may be set at the top of the organisation, it is the balance of power and trust within the adviser-farmer relationship which ultimately governs the nature and outcome of advice at the farm level. This accords with the view that power is exercised by individual actors and the outcomes of power relationships have their significance to individual actors even if they are ultimately explained by institutional structures (Leeuwis 1993b; Scoones and Thompson 1994; Gray et al. 1997).

8.5.2 Adviser-farmer knowledge relationships

This research has revealed that the knowledge processes in which advisers and farmers engage occur within three different types of adviser-farmer knowledge relationship. These can be distinguished on the basis of the balance of power or influence within the relationship determined primarily by the style of the advisers' delivery of advice in terms of whether he acts as an expert or a facilitator, and by the farmers' response. As these most accurately describe the relationship between farmers and agronomists, the following typology refers exclusively to agronomists. Table 8.1 sets out a matrix which associates these knowledge relationships with soil best management practice outcomes.

Agronomists are proactive experts (A)

Some advisers, predominantly agronomists, through their extensive and regular contact with farmers, as one independent agronomist interviewed put it, '*have a very strong influential power with the farmer*' with regard to farming decisions. Farmers come to rely on them as experts and develop a high dependence on their advice; they delegate decisions to them and have '*complete faith*' in their expertise. The farmer receives reassurance, and appreciates the advisers' commitment to him; in return the adviser values the farmers' loyalty. In this relationship advisers behave as experts, they are confident and proactive and in a powerful position. Being a confidant and '*having the ear of the farmer*' as they walk around the farm makes these advisers influential in terms of best management practice for soil; often they are the first person the farmer will talk to if thinking about changing practices or going into a scheme. The advisers often take a paternalistic view, they want to protect farmers and feel responsible for the outcomes of their decisions, for example, they describe their concern when farmers are attracted to new practices for the wrong reasons. As one said '*what I'm most keen on is that they don't go into it blindly attracted by the* *big shiny pieces of metal*'. Some advisers even demonstrated a disrespectful or even contemptuous attitude, as one agronomist said '*I do nearly all the rotations, I don't know why, I shouldn't need to, I mean what the hell do farmers do? What do they actually do?*'. The relationship in this context is characterised by a lack of consultation, dialogue, trust and respect. Advisers tell farmers what to do and can often be dogmatic; '*I never withdraw a recommendation*' or '*no, you listen to me*' are statements that epitomise this. In such a relationship farmers are more likely to contest, query, transform, or ignore advice and effective knowledge integration is less likely to occur.

In terms of influencing farmer decisions about soil management if the adviser is progressive and convinced of the benefits of best management practice this type of relationship can offer opportunities for advancing best management practice at the farm level. These advisers are confident in their abilities and are not risk averse. As one said '*I'm not happy for it [erosion]. It looks terrible, it's ridiculous and I will give them some advice. I don't usually loose customers by being rude to them, although I'm quite rude.*' (see column A1 in Table 8.1). Conversely if advisers are more conventional and are reluctant to endorse soil best management practice, they will persuade the farmer not to consider it (see column A2 in the Table 8.1). Indeed if their motives are purely profit seeking they may advise the farmers to undertake unsympathetic practices which degrade the soil.

<u>Agronomists are reactive experts (B)</u>

In contrast to (A) other advisers might still be called on to provide expert advice but they are in fact simply being reactive; they are responding to farmers requests or '*getting sucked into what farmers ask for without really thinking about it*'. Retaining clients by responding to their demands is the priority for agronomists in this relationship, particularly given the competitive or 'cut throat' nature of the agronomy industry and vulnerability of the agronomists position. In this relationship the farmer is powerful, and dictates the terms of the relationship and the nature of the advice. In circumstances where the farmer demands that advice ensures a sustained profit for the farm, agronomists will not compromise their client relationship by including what they perceive as risky best management practice, even if they are committed to sustainable soil management. As the comment '*there are environmental things he* *[agronomist] would dearly love to advise everybody on but sometimes it's difficult because the farmers say I don't want to know about that I just want so and so*' shows (this corresponds to column B2 in Table 8.1).

However, where farmers themselves are interested in soil best management practice, advisers will respond, for example, farmers' enthusiasm for reduced tillage has been the incentive for advisers to take more interest and seek training in the practice in response to their farmers interests (this corresponds to B1 in Table 8.1). Failure to support these changes through competent advice or interest can lead to farmers sacking the agronomist and excluding advisers from the learning process by choosing to learn though other networks of knowledge. In both situations, whether farmers' priorities are profit seeking or sustainable soil management, credibility and demonstration of competence are important and agronomists are in a vulnerable position.

Relationships B) like A) are characterised by a lack of consultation, trust and dialogue. For example, one farmer hired two agronomists and compared their advice to check up on them, other farmers talk of swapping or sacking their advisers if they fail to provide adequate advice. Farmers are also known to shift their loyalty to other 'more switched on advisers'. In this context integration of knowledge between adviser and farmer is poor.

Farmer responses in A and B knowledge relationships

At the interface with farmers the nature and quality of the social relationship determines how farmers respond to advice. Farmers accept, question, ignore, contest, compare, and transform this advice depending on how they value the competence of the adviser, whether they are confused by too much or contradictory advice, whether they trust the source of advice, whether it compares with their own knowledge and experience, whether they are reluctant to change because of entrenchment in traditional practice and whether they just wish to simplify the advice. All these interacting factors mean that farmers' use of advice will be an individual choice and will depend to some extent on the context of its delivery. Ward and Munton (1992) found that farmers ultimately decide what advice to take and what to reject; and others have described subtle games of power that unfold in the way that advisers manipulate, manage and even exploit the farmer relationship (Hawkins 1991; Lyon 1996); while the importance of trust has been identified by many commentators (Jones et al. 1987; AERDD 1996; Cooper 1999).

Table 8.1 Soil best management practice outcomes of different agronomist-farmer knowledge relationships.

A) Proactive		**B) Reactive**	
A1	**A2**	**B1**	**B2**
Adviser interested in best management practice	Adviser committed to conventional management	Farmer interested in best management practice	Farmer committed to conventional management
Best management practice implemented	Conventional management, possible degradation	Best management practice implemented	Conventional management, possible degradation
I have banged the gong for many years. I've kept on about seedbeds and soil wash. Oh yes I would haul them over the coals and say 'for Christ sake look it's ridiculous. You're loosing half your field, apart from polluting the river.	*Agronomists talk about, for example, putting maize in the ground – 'maize should be in the ground by now; everyone else has done it'. Whether the soil's capable or not - it's the pressure.*	*Word soon gets out if you have a switched on agronomist* *We had an independent agronomist whom we got rid of because he wasn't – he didn't like it all [reduced tillage].*	*There are environment things he [agronomist] would dearly love to advise everybody on but sometimes it's difficult because the farmers say I don't want to know about that I just want so and so....*

Where advisers behave as experts providing proactive or reactive advice, as in relationships A and B described above, without consulting, respecting or understanding the farmer, often in a climate of power imbalance, mistrust and confusion, their advice is more likely to be questioned, criticised, ignored or changed. In this context integration of knowledge from both parties is least likely to occur since dialogue with the farmer is minimal. Under these conditions farmers are more likely to negotiate or modify advice. Some were described as playing clever 'mind games' with their agronomist regarding prophylactic agrochemical applications, others add 10% to fertiliser recommendations while some simplify the recommendation for ease, or use two bags of fertiliser rather than three because that is '*what they had in the shed*'. These interpretations and transformations add a further layer of modification to that undertaken by the advisers described in the results chapters, and represented in Figure 8.1.

Agronomists are facilitative (C)

The third knowledge relationship can be described as facilitative, with advisers working in a one to one partnership with farmers, setting strategies and objectives together based on the farmers' own needs and combining the advisers and farmers experience and sources of knowledge. Unlike the first two knowledge relationships, this is an equitable relationship where understanding, dialogue and shared knowledge, characteristic of a trusting and respectful one to one farmer-adviser relationship, can provide the right context for knowledge integration and facilitating farmers change to soil best management practice.

Advisers and farmers both bring their own experience, ideas and insights to these relationships, whilst farmers benefit from advisers' inputs, these results reveal that farmer knowledge and experience are an undeniable resource for the adviser who integrates this with his own knowledge when providing advice. In the process of incorporating farmers' knowledge, they compromise, for example, one agronomist asked '*Do I defer to his [the farmers] logic or do I defer to mine?*' and make joint decisions. Dialogue, explaining principles, listening, talking the same language and shared understandings are all central to ensure knowledge integration and as such enable facilitation and empowerment of farmers to undertake their own decisions. This agrees with Engel's (1997:53) observation that 'from the outside it is striking that the more closely one approaches the field level, the more dominant role in integrating knowledge appears to be played by interpersonal communication mechanisms'. Figure 8.2 sets out diagrammatically the different knowledge relationships described above and demonstrates the relationships between influence (and power) and knowledge integration.

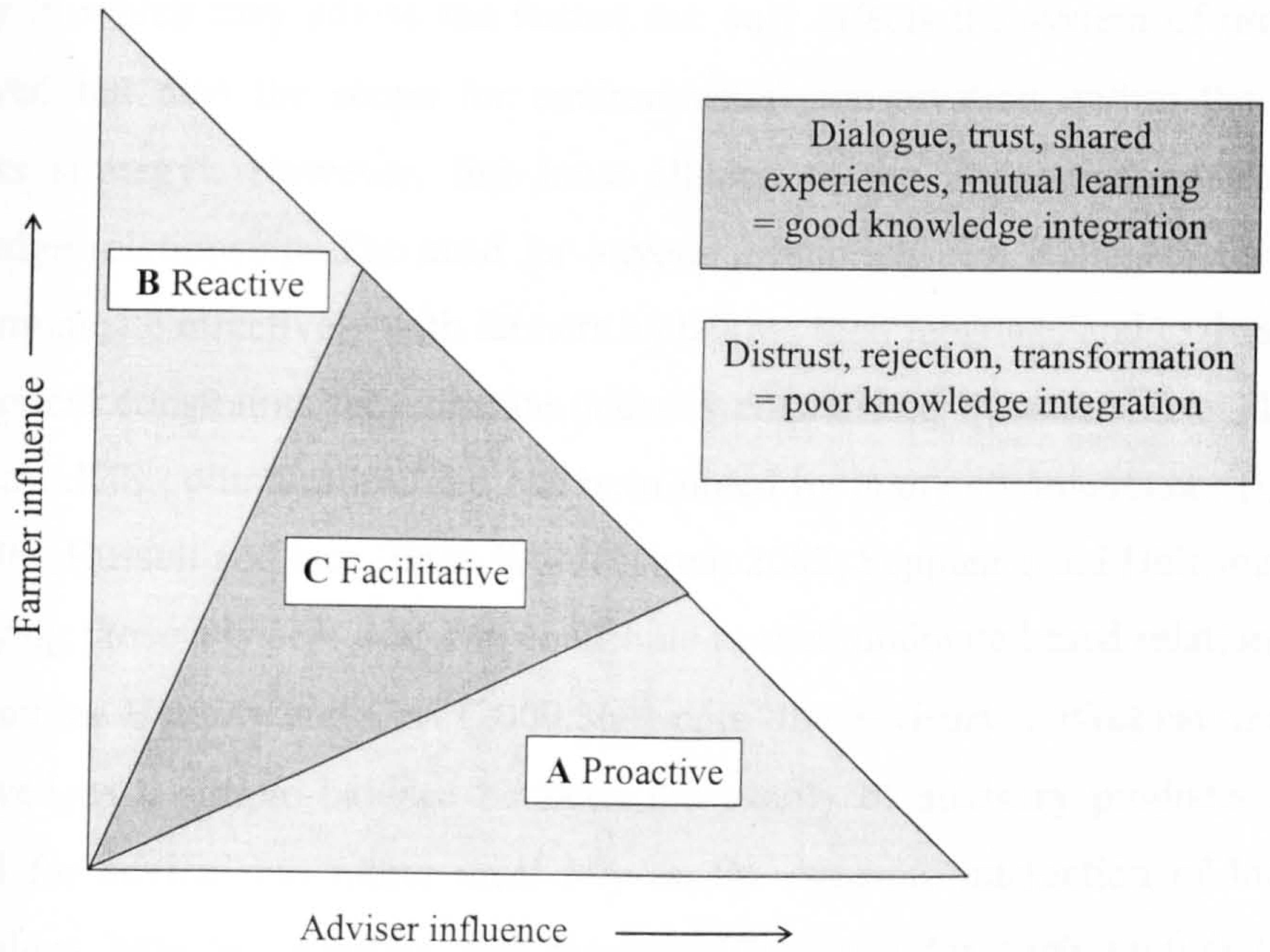


Figure 8.2 The relationship between influence and adviser (agronomist)-farmer knowledge relationships.

8.5.3 Facilitation and integration implications

The observations from this study concur with those of other researchers who have noted that established and trusting adviser-farmer relationships are central in underpinning effective face to face advice (Jones et al. 1987; AERDD 1996; Cooper 1999; Juntti and Potter 2002). Aspects of trust have frequently been highlighted as important for adviser-farmer relations and this is consistent with these results. However, the complex relationship between trust and knowledge and the way trust evolves through long-term relationships and dialogue is an area not sufficiently explored. As discussed earlier it is such relationships that enable knowledge integration. Where there is distrust or where advisers take an expert authoritarian approach integration is least likely, as Gray et al. (1997:99) point out, in such relationships of power imbalance, the extension process becomes 'no more than struggle for influence over behaviour, rather than a mutual endeavour for a commonly beneficial outcome'.

The importance of the quality of the communication between advisers and farmers has been noted by other researchers (Engel 1997; Waldenstrom 2002). For example, Ward and Munton (1992:133) suggest with respect to conservation advisers that 'the manner in which they advise the farmer not only affects the system of production employed but also the scope for environmental conservation within the farmers business strategy'. However, few have alluded to the integrative nature of the knowledge relationship. The need for anyone promoting best management practice to communicate effectively with farmers by talking their language and understanding the practical constraints they operate under is emphasised by actors throughout the different AKIS communities, and has been noted by many commentators (Ison and Fell 2000; Russell and Ison 2000; Waldenstrom 2002; Seppanen and Helenius 2004). Identifying those advisers who can contribute to such dialogue based relationships is important, as Hemidy and Cerf (2000:366) note 'the advisory market can no longer be viewed as a simple balance between the supply of advisory products and the demand for advice' but rather must rely on the dynamic interaction of long-term partnerships between advisers and farmers. The need for such mutual learning between policy makers, street level bureaucrats and the target group was also identified by Juntti and Potter (2002) for the successful implementation of agri-environment schemes. These results also suggest that dialogue and shared experiences can contribute towards re-skilling of both advisers and farmers, a task which some argue is critical to achieving sustainable agriculture (Roling 1988; Curry and Winter 2000).

Arguably agronomists, who demonstrate the greatest empathy and understanding of farmers and their practices and have most opportunities for regular dialogue, are better equipped to participate in such mutual learning than other advisers. They have an intimate understanding of farmers' practices and tend to share the same views as farmers, particularly in terms of economic decisions and the level of unavoidability in some practices. They see the farming community as willing to comply with soil best management practice but constrained by costs, weather and the pressure to meet schedules and stress that an understanding of these constraints is central to achieving change to soil management.

However, as the discussion revealed earlier not all agronomists are well placed to foster such relationships. Others have also found that distrust and imbalance of power makes some farmers reluctant to share their knowledge with advisers. Some believe that the advisers will take this knowledge and then go onto distribute it to other clients; indeed Leeuwis (2000) considered this as their primary role. Lyon (1996) described agronomists taking a similar exploitative role, suggesting that agronomists used farmers unwittingly as guinea pigs in trialling new technologies. Hawkins (1991) also described a cynical manipulative management of the relationship by commercial agronomists. In such contexts of mistrust or imbalance of power, integration is less likely to be achieved.

The potential of agronomists/consultants as influential messengers in the delivery of environmental protection information has been recognised before (Jones et al. 1987; Archer 2001; Dampney et al. 2001). ADAS already taps into consultant network when promoting MANNER etc, while projects like Landcare and SMI run workshops and demonstration days for advisers. Some individuals, however, have reservations about using advisers as messengers because of their limited skills in some soil management practices and see a need for improvement and standardisation of competence within the community before harnessing them. Advisers themselves have mixed views as to their role, some will oblige if given the resources while others are reluctant to commit valuable time and resources to matters they do not consider their responsibility, others just do not have the interest. FWAG advisers also place great value in cultivating relationships with farmers and represent another community, which could be exploited in delivering best management practice messages, particularly as the results here show they have a greater conviction towards soil protection. However, they are fewer in number, have less regular contact with farmers than agronomists and are not sufficiently competent in arable practices to command the respect of farmers. They are, however, generally accepted by farmers as trustworthy, impartial and do not suffer the same tensions as agronomists in terms of having to provide financially viable arable advice. It is worth noting that a previous study in the Landcare more farmers thought that FWAG should be more involved in best management practice advice than the Environment Agency, but, although agronomists were rated as one of the most important sources of advice by farmers, farmers did not suggest that they deliver best management practice advice (Seymour 1998b).

8.6 Policy implications

8.6.1 Introduction

In this final section of Chapter 8 some implications for policy are highlighted drawing on the results of the research. Advisers have been shown to be important players connecting research and practice in the context of knowledge and soil best management practice. However, they are constrained and enabled in providing soil best management practice knowledge to farmers in different ways. Only by enhancing the enabling factors and reducing the constraining factors, can the true potential of advisers can be realised in facilitating soil best management practice, and progress in achieving policy aims of sustainable soil management be made.

8.6.2 Addressing constraining and enabling factors

Clearly advisers have diverse interests and skills and differential access to resources, education, experience, information and support. Consequently they have competing conceptions of soil management needs and different propensities to participate in any soil best management practice transition, as revealed in Table 8.1. In policy terms this suggests that they should not be treated collectively as a homogenous group.

The following factors that constrain advisers in facilitating soil best management practice have been identified in this research:

- Fragmented AKIS leading to uneven access to information
- Gaps in advisers competence and skills
- Advisers' and farmers' lack of confidence in best management practice
- Economic imperatives for farmers and advisers
- A science-practice gulf, both institutional and social

The following factors that enable advisers in facilitating soil best management practice have been identified in this research:

- Ability to network and access information through less formal linkages

- On-going influence of advisers on the farm
- An adaptable and diverse adviser community
- Good experience and ability to learn in practice
- Demonstrated willingness to access available information

Although listed separately these factors are not unrelated as the following discussion shows.

8.6.3 Suggested policy actions

Advisers are adaptable and responsive to change in a continually evolving AKIS. Interactions between farmers and advisers are not one-off affairs, the relationships change and develop as do perceptions and goals, as one agronomist noted '*the job is continuously evolving*'. In the same way the nature of the interaction between the research/policy and the advisory community is continuously shifting with advisers given different responsibilities and greater opportunities for involvement in soil best management practices initiatives. This dynamic response to changing conditions will be important considering the future soil management policy proposals outlined in Chapter 2. Given that adaptability and autonomous behaviour are features of the advisory community, it may be possible to manipulate conditions in the AKIS to encourage their greater participation in soil best management practice. As Engel (1990, 1997) notes the multiplicity, relative autonomy of actors and diversity of the AKS are strengths and might provide leverage points for effective knowledge management. These 'leverage points' or conditions as they relate to soil best management practice, which can be manipulated, are discussed below (and represented on Figure 8.3) and proposals are made for improving the advisers' role in facilitating sustainable soil management.

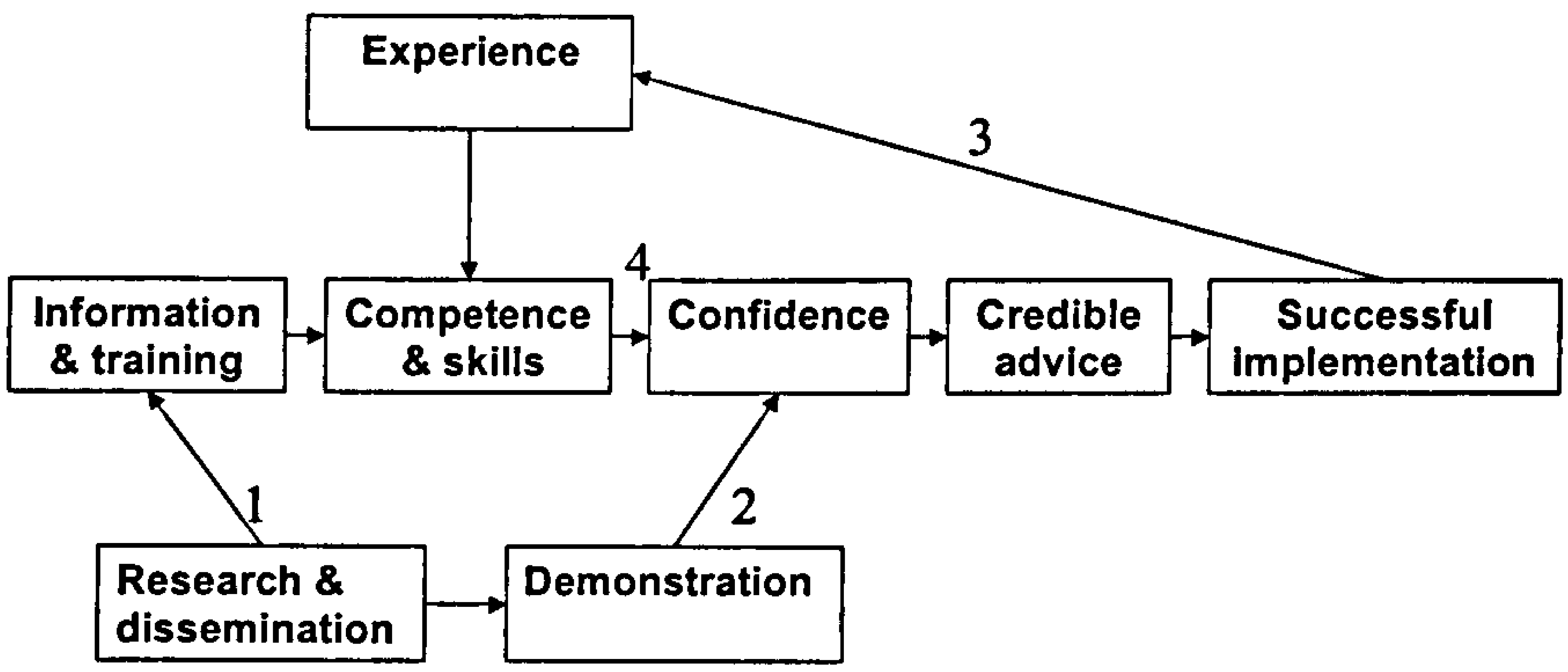


Figure 8.3 Overcoming advisers' constraints to facilitating soil best management practice.

Key to arrows:

1. Making access to research easier for advisers through improved linkage mechanisms and improving integration through dialogue
2. Demonstrating effectiveness of soil best management practice thereby improving confidence in these practices
3. Successful implementation provides learning in practice experience which increases competence and skills
4. Improved competence and skills increases confidence in soil best management practice

Improving integration at the advisers' interface with research/policy

Improving AKIS integration through better information flow and enhancing knowledge integration through dialogue are central to this first proposal. Although advisers are enabled by a dynamic and flexible AKIS, in which information can be quickly and effectively moved through informal networks and alliances, some advisers are not accessing information to its full extent. Chapter 5 described elements of a vertically and horizontally fragmented AKIS where institutional linkages are weak. Improving linkage mechanisms and therefore advisers' access to research outputs could provide the right conditions for more effective knowledge integration and address some aspects of the so called gulf between science and practice. This action is represented by arrow 1 in Figure 8.3. Rather than simply increasing the number of linkage mechanisms however, effort should be focused on making access to current mechanisms easier for certain actors, who are presently constrained in accessing them. These are: independent agronomists, who struggle to maintain networks; contractors and merchants, who appear to be 'out of the loop' in terms of soil best management practice information; and distributor agronomists, who are well supplied with agrochemical information, but less so for cultivation and soil management. In terms of the methods used, results in Chapter 5 showed that advisers demonstrate a preference for using personal contacts with other AKIS members. Linkage mechanisms such as workshops, with an element of social interaction, should therefore be given priority over publications.

Although improved AKIS integration can be achieved through more effective linkage mechanisms between research and advice, the research has shown that there needs to be a greater element of dialogue and feedback to achieve knowledge integration across the research-advice interface, rather than a reliance on conventional top-down delivery mechanisms. Mechanisms such as publications and training are the characteristics of an AKIS which can exaggerate the dissonance between the two groups. Part of this dialogue should ensure that researchers can understand real farming constraints and can incorporate anecdotal evidence from the practical community and appreciate its value and that advisers can learn to understand and appreciate the scientific basis of researchers' recommendations.

Consultation with the practical community about research priorities and in preparing best management practice guides should also be key processes, as should soliciting feedback as well as methods by which feedback can be utilised. These are clearly ambitious proposals and time, and the appropriate fora, will be needed in which advisers and researchers can re-orientate their approaches. Researchers involved in SUNDIAL-FRS and SMI demonstrated that researchers were willing to learn and listen about real farming conditions suggesting that given time such dialogue could be effective.

Improving advisers' confidence in soil best management practice options

Advisers need to be convinced that soil best management practices work, are practical and profitable before they have enough confidence to provide advice about them on farm. Demonstration of the effectiveness of soil best management practice should therefore be a central role for researchers. This can be done using demonstration farms and real life case studies. Part of this demonstration should entail the provision of convincing facts and figures which farmers and advisers set great store by, as demonstrated in the popularity of the SMI handbook and case studies. If the research community can provide credible soil best management practice options which do not risk farm profits then this goes some way to addressing perceived economic constraints and in turn will help advisers (and their farmers) to overcome their risk adversity. This proposal is represented by arrow 2 on Figure 8.3.

Improving integration at the advisers' interface with farmers

Section 8.5.2 described the significance of different knowledge relationships between advisers and farmers and identified the most promising conditions and relationships in which facilitation and knowledge integration could be achieved. Although developing long-term trusting facilitative relationships appears to provide the best situation for facilitating a transition to sustainable soil management, such relationships are not necessarily common and it may be unrealistic to expect that they can be produced artificially. Instead, convincing farmers and advisers about the effectiveness of soil best management practices within proactive and reactive relationships provides the key. By proving these practices are 'win-win' and removing the economic constraints it may even lead to more equitable relationships where adviser and farmer share the same expectations. Proof and conviction in these practices again rely on information, demonstration and experience, as represented by arrows 1, 2 and 3 respectively on Figure 8.3.

Improving advisers' skills, competence and confidence

The availability of decision support systems (DSS) such as MANNER and SUNDIAL-FRS, opportunities for more efficient nutrient management, and new cultivation methods such as reduced tillage make new demands both on adviser technical skills and on their understanding of the scientific principles that underpin them. Comments reveal that advisers together with farmers find many of these best management practices complex to implement. Whilst the challenges these present for farmers are well documented (Roling and Jiggins 1994; Park et al. 1997; Petrzelka et al. 1997), the fact that advisers face an equally difficult task has been somewhat ignored (Tebrugge and Bohrnsen 2001; Coughenour 2003). A further complication is that these practices are all relatively young and the knowledge base for them is continuously changing and expanding as experience in the community grows. This was clearly evident in the case of reduced tillage.

The way that advisers generate, integrate and transform knowledge has implications for the successful transition to sustainable soil management. Reliance on their own experiential learning and local knowledge may be problematic for advisers in terms of embracing soil best management practice. Although it equips them to deal with the familiar it fails when they encounter something outside their experience such as the more technically demanding nutrient management. In addition lack of hands-on experience in cultivating clearly hinders advisers' ability and credibility in advising on cultivation practices and reduced tillage in particular. Although emphasis has been placed on re-skilling farmers to equip them for sustainable agriculture few have considered the fact that advisers equally need to be re-equipped if they are to support farmers in the transition to sustainable soil management. The results have shown that lack of confidence in certain skilled areas such as nutrient value of manures and cultivations have made advisers either reluctant to advise on these practices, or in some cases provide inappropriate advice. Only through developing competence and skills in soil best management practice can advisers have confidence to advise them on-farm (this is represented by arrow 4 in Figure 8.3).

The way that advisers learn through integrating experience and information from research has important messages for policy. High levels of training and attendance at workshops confirm that advisers are taking opportunities to exploit formal sources of knowledge, however, advisers' skills, competence and therefore confidence in soil best management practice are closely related to their ability to experience them. Although provision of technical knowledge through training and literature will continue to be important for re-skilling advisers, enabling them to build up experience in certain practices on-farm is clearly an important aspect of facilitating their transition to soil best management practice. Advisers therefore need to be encouraged to continue to learn through practice. This can be done by making training and demonstration more locally relevant, and most important, participatory with a hands-on element such as workshops, which have proved so successful in the Landcare project. Allowing some appraisal and credibility check of tools such as DSS should also be an important part of the evaluation process, a process that was truncated prematurely in SUNDIAL-FRS. Arrows 1 and 3 on Figure 8.3 represent different ways in which advisers can access these sources of knowledge to improve their skills and competence.

Figure 8.4 locates the three agronomist-farmer knowledge relationships (A, B, C) described above within a model of pathways for achieving sustainable soil management. The model is based on the farmer' and advisers' respective engagement with sustainable soil management, where this engagement is understood to be a function of concern about, and competence in, soil management, and confidence in the effectiveness of soil best management practices. The x and y axes

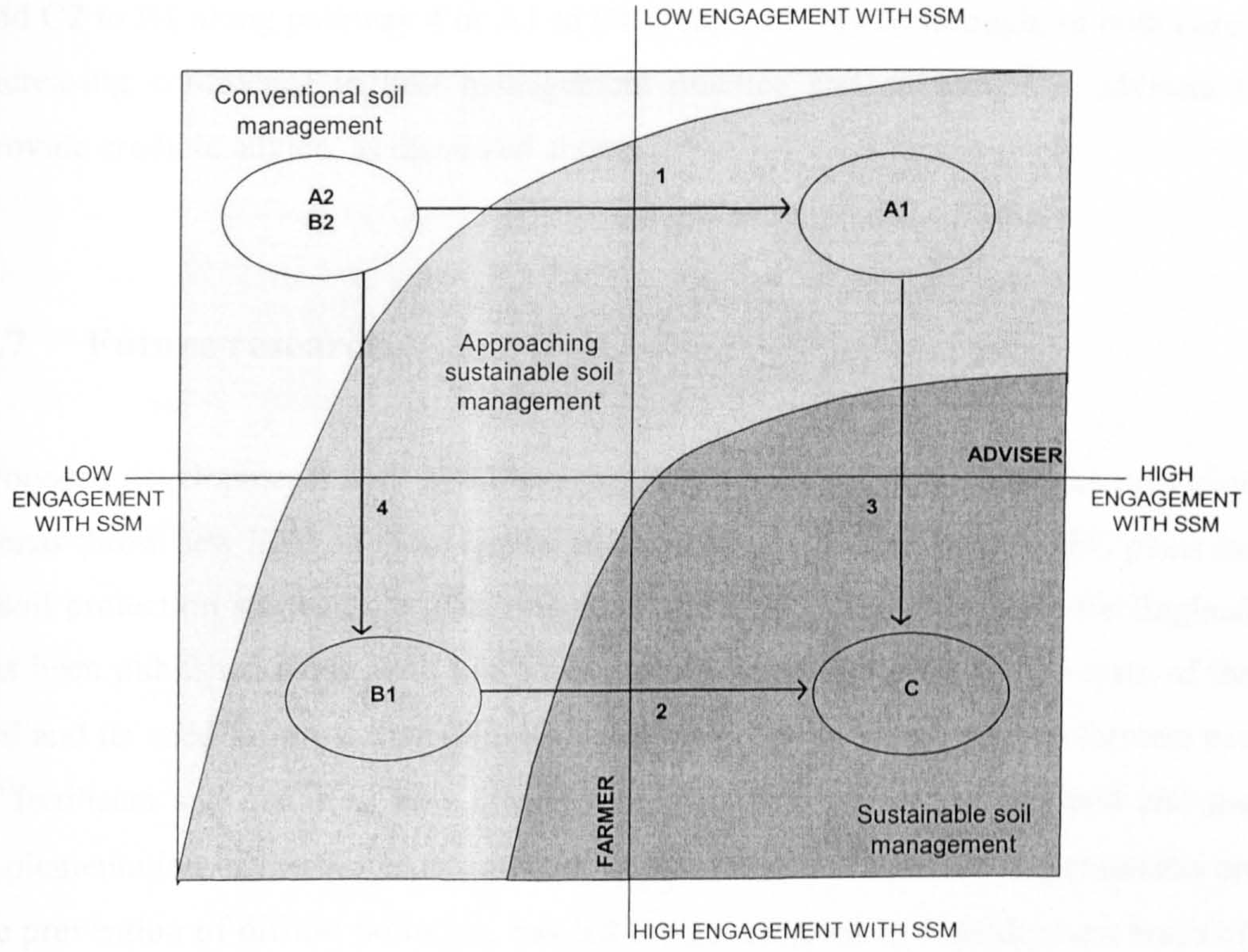


Figure 8.4 A model for pathways (arrows) towards sustainable soil management for agronomist-farmer knowledge relationships.

represent respectively advisers' and farmers' extent of engagement with sustainable soil management from conventional soil management through to sustainable soil management. As the model demonstrates knowledge relationship C1 has most potential for achieving sustainable soil management, where adviser and farmer are fully engaged with sustainable soil management. Conversely knowledge relationship C2 occurs where advisers' and farmers' commitment to conventional soil management coincide. Knowledge relationships A2 and B2 fall in the conventional soil management sector of the model and describe a situation where neither farmer nor adviser respectively are engaged. Knowledge relationships AI and B1 are approaching sustainable soil management with the advisers' and farmers' respective engagement with sustainable soil management leading the transition. The extent of this transition towards full engagement can be represented by pathways, depicted as arrows on Figure 8.4. Pathways for achieving the transition to sustainable soil management are provided by increasing advisers' engagement with sustainable soil management (moving A2 and C2 to A1 along pathway 1 or B1 to C1 along pathway 2) and increasing farmer engagement with sustainable soil management (moving B2 and C2 to B1 along pathway 4 or A1 to C1 along pathway 3) through, in both cases, increasing confidence in best management practice and enabling the advisers to provide credible advice, as discussed above.

8.7 Future research

Proposed developments both in the soil protection policy and in the advice provision arenas throw new light on these results and on a future research agenda. EU plans for a soil protection strategy are gathering pace, the First Soil Action Plan for England has been published along with key Environment Agency reports on the state of the soil and its need for protection. Nitrate Vulnerable Zones, which control farmers use of fertilisers and manures, now cover more than 50% of land in England and the implementation of the Water Framework Directive, which has a strong emphasis on the prevention of diffuse pollution, has led the government to consider new ways of implementing it on-farm. In 2005 farm Soil Management Plans will be introduced as part of Good Agricultural and Environmental Conditions and become a strong component of compliance within the new CAP. Clearly the emphasis on sustainable soil management is growing, and this will lead to the demand for implementation of more soil best management practice within agriculture, either voluntarily or enforced through regulations. Concerning advice provision, the agricultural community are just starting to realise the implications for the industry (Farmers Weekly 2004a,b). The recent publication of the *Rural Strategy* by DEFRA together with proposals made for EU nations to provide a state farm advisory service by 2007 herald a new and challenging phase for the advisory community in England. Given these developments, the need to complement this research with further investigations of the advisers who might provide such a service for the future is clear.

The diversity of the AKIS advisers, their range of abilities and different understandings and commitments they hold regarding sustainable soil best management practice and the agency they demonstrate will inevitably lead to what Wilson (2001) predicted would be an uneven transition away from productivist modes of thought and action towards sustainable agriculture. By understanding the world of the farm advisers, their motivations and identifying patterns in the different strategies they employ in negotiating soil best management practice, research can inform the transition to sustainable soil management advice in England. Advisers have been shown to be important players connecting research and practice in the context of soil best management practice. However, rather than playing a traditional role of messenger for the research and policy community, they negotiate, interpret and transform their soil best management practice messages. The importance of this interpretative role is amplified because of the nature of soil best management practices, which are non-prescriptive and evolving practices, open to negotiation and transformation. If future policy continues to rely on a voluntary participation with sustainable soil management, understanding advisers' individual interpretations and motivations of best management practice for soil will remain important.

Whilst there is recognition of a diverse and dynamic adviser community in England (Winter 1995; Garforth et al. 2003) the knowledge transfer model still underpins many attempts to conceptualise advice provision (Padel 1984; Gasson and Hill 1996) and reviews of advice provision persist in using the term 'knowledge transfer' (Archer 2001; Dampney et al. 2001; DEFRA 2002). Conceptualising knowledge processes in the England AKS has been restricted to examination of patterns of linkages and their efficiency and exposing diversity and fragmentation (Winter 1995). These all, however, fail to describe or explain the knowledge processes advisers engage in and are an inadequate basis for understanding the advisers' role in the transition to sustainable soil management.

Such a focus primarily on macro-level structural issues with little attention to micro-level or social issues is insufficient. The transition to sustainable soil management will take place in particular social, economic and ecological contexts and the interpretation of these contexts in term of constraints and opportunities is important at macro- and micro-levels. Using an actor-oriented AKIS approach offers a new understanding of the advisers' role at the micro-level as an autonomous agent within the larger constraining and enabling frameworks of the AKIS. This perspective understands that knowledge generation and utilisation are not just a matter of technical efficiencies but involve aspects of control, authority and power embedded in social relationships. This is more suited to studies of advisers who work in the context of an industry in economic crisis, yet increasingly have to accommodate environmental policy influences and regulation. Future research should therefore consider using the actor-oriented approach as a basis as opposed to traditional positivist perspectives. Action research and participatory research are promising methodologies based on such an approach and are already successfully used in other countries; these might yield the appropriate tools for future research into advisers' learning and engagement with knowledge processes in the context of best management practice for soil.

REFERENCES

Accent Marketing and Research. 2002. *Farmer Surveys of Knowledge and Attitudes to Diffuse Farm Pollution*. London, Accent Marketing and Research.

Arce, A.C. and Long, N. 1988. The dynamics of knowledge interfaces between Mexican agricultural bureaucrats and peasants: a case study from Jalisco. *Boletin de Estudios Latinamercanos y del Caribe* 43, 5-30.

Arce, A.C. and Long, N. 1992. The dynamics of knowledge: interfaces between bureaucrats and peasants. In: Long, N. and Long, A. (Eds), *Battlefields of Knowledge: the Interlocking Theory and Practice of Social Research and Development*. London, Routledge, 211-246.

ADAS. 1998. *Attitudes Towards Changing Practices in the Management of Animal Manures Outcome of Focus Groups*. Report to RMED, MAFF.

ADAS. 2000a. *Managing Livestock Manures*.

ADAS. 2000b. *Farmers Voice Survey*.

ADAS. 2000c. *ADAS Research Review*.

Agricultural Extension and Rural Development Department (AERDD). 1996. *Assessment of Techniques for Persuading Farmers to Adopt Nitrate Reducing Practices*. Report for MAFF by Agricultural Extension and Rural Development Department, University of Reading and ADAS.

Agricultural Food and Fisheries Research Funders Group. 1999. *Second Report of the Agricultural Food and Fisheries Research Funders Group*. www.maff.gov.uk/ research/publications/funders_2pdf; December 2000.

Allan, G. and Skinner, C. (Eds). 1991. *Handbook for Research Students in Social Sciences*. London, The Falmer Press.

Angell, B., Francis, J., Chalmers, A., and Flint, C. 1997. *Agriculture and the Rural Economy Information and Advice Needs*. Report to MAFF by ADAS.

Archer, J. 2001. *Review of Current and Recent Knowledge Transfer Activities in Relation to Environmental Protection in Agriculture*. Report to RMED, MAFF.

Arksey, H. and Knight, P. 1999. *Interviewing for Social Scientists*. London, Sage Publications.

Auerswald, K. and Kutilek, M. 1998. A European view to the protection of the soil resource. *Soil Tillage Research* 46, 9-11.

Baldock, D. and Mitchell, K. 1995. *The Implications for Soils of the CAP.* A report to the Royal Commission of Environmental Protection by the Institute of European Environmental Policy, London.

Balfour, Lady Eve. 1943. *The Living Soil.* Faber and Faber, London.

Balzac, Honore de. 1998. *Sons of the Soil.* Translated by Katharine Prescott Wormeley, PDM Classics, Project Gutenberg Release No.1417 (August 1998).

Beard, G.R. 1989. *An Assessment of the Principles of the Soil Protection in the UK.* Volume II Reviews of the current major threats. ITE, NERC.

Bergsma, E. 1996. The bridge between land use and advisers. *Land Husbandry, the International Journal of Soil and Water Conservation* 1, 81-93.

Bergsma, E. 2000. Incentives of land users in projects of soil and water conservation, the weight of intangibles. *Geojournal* 50, 47-54.

Bell, A. 1998. Changing from adviser to consultant: the consultants' experience. In: Wallace, I. (Ed), *Rural Knowledge Systems for the 21st Century* AERDD, ADAS, SAC Proceedings, 199-203.

Berlo, D.K. 1960. *The Process of Communication.* New York, Holt, Rinehart and Winston.

Black, A.W. 2000. Extension theory and practice: a review. *Australian Journal of Experimental Agriculture* 40 (4), 493-502.

Blackmore, C. 2002. Learning about learning as systemic practice. In: *Farming and Rural Systems Research and Extensions Conference 5th IFSA European Symposium Proceedings*, 548-556.

Blaikie, P. 1985. *The Political Economy of Soil Erosion in Developing Countries.* London, Longman.

Blaikie, P. and Brookfield, H. 1987. *Land Degradation and Society.* London, Methuen.

Blum, A. 1991. The agricultural knowledge transformation cycle. *Quarterly Journal of International Agriculture* 33, 321-333.

Blum, W.E.H. 1990. The challenge of soil protection in Europe. *Environmental Conservation* 17, 72-74.

Blum, W.E.H. 1993. Soil protection concept for the Council of Europe and integrated soil research. In: Eijsackers, H.J.P. and Hamers, T. (Eds), *Soil and*

Environment Vol 1 Integrated Soil and Sediment Research: a Basis for Proper Production. Dordrecht, Kluwer Academic Publisher, 37-47.

Boardman, J. 1988. Public policy and soil erosion in Britain. In: Hooke, J.M. (Ed), *Geomorphology in Environmental Planning.* Chichester, Wiley, 33-50.

Boardman, J. 1990. Soil erosion in Britain: costs, attitudes and policies. *Social Audit Paper* No. 1. Education Network for Environment and Development, University of Sussex.

Boardman, J. 1996. Soil erosion by water: problems and prospects for research. In: Anderson, M.G. and Brooks, S.M. (Eds), *Advances in Hillslope Processes.* Volume 1. Chichester, Wiley, 489-505.

Boardman, J. 2001. Don't Blame the Climate. *The Guardian.* Wednesday November 8, 2001.

Boardman, J. 2002. The need for soil conservation in Britain – revisited. *Area* 34 (3), 419-427.

Boardman, J., Poesen, J. and Evans, R. 2003a. Socio-economic factors in soil erosion and conservation. *Environmental Science and Policy* 6, 1-6.

Boardman, J., Evans, R. and Ford, J. 2003b. Muddy floods on the South Downs, southern England: problems and responses. *Environmental Science and Policy* 6, 69-83.

Bouma, J. 1997. The role of quantitative approaches in soil science when interacting with stakeholders. *Geoderma* 78, 1-12.

Bourdieu, P. 1985. *Outline of Theory of Practice.* Cambridge, Cambridge University Press.

Bourque, L.B. and Fielder, E.P. 1995. *How to Conduct Self Administered and Mail Surveys.* Thousand Oaks, USA, Sage Publications.

Box, De la Rive, L. 1989. Knowledge, networks and cultivations: cassava in the Dominican Republic. In: Long, N. (Ed), Encounters at the Interface. Perspectives on Social Discontinues in Rural Development. *Wageningen Studies in Sociology* 27. Wageningen, The Agricultural University, Pudoc, 165-182.

Box, De la Rive, L. 1990. Agrarian knowledge networks: a conceptualisation. In: From Shared Ignorance to Common Knowledge: Knowledge Networks in the Atlantic Zone of Costa Rica. *Wageningen Studies in Sociology* 28. Wageningen, The Agricultural University, Pudoc, 1-8.

Bradbury, N.J., Whitmore, A.P., Hart, P.B.S. and Jenkinson, D.S. 1993. Modelling the fate of nitrogen in crop and soil in the years following the application of 15N-labelled fertilizer to winter wheat. *Journal of Agricultural Science (Cambs)* 121, 363-379.

British Society of Soil Science (BSSS). 1997. *Soil. The Vital Resource and Life Support System.*

Brookes, P.C. and McGrath, S.P. 1984. Effects of metal toxicity on the size of microbial biomass. *Journal of Soil Science* 35, 341-46.

Brotherton, I. 1991. What limits participation in ESA? *Journal of Environmental Management* 32, 241-249.

Bullock, P. 1987. Soil erosion in the UK- an appraisal. *Journal of the Royal Agricultural Society of England* 148, 144-157.

Bullock, D.S. and Bullock, D.G. 2000. From agronomic research to farm management guidelines. A primer on the economics of information and precision technology. *Precision Agriculture* 2 (1), 71-101.

Burgess, J., Clark, J. and Harrison, C.M. 2000. Knowledge in action: actor network analysis of a wetland agri-environment scheme. *Ecological Economics* 35, 119-132.

Burton, M., Rigby, D. and Young, T. 1999. Analysis of the determinants of adoption of organic horticultural techniques in the UK. *Journal of Agricultural Economics* 50 (1), 47-63.

Busch, L. 1978. On understanding - understanding: two views of communication. *Rural Sociology* 43 (3), 450-473.

Buttel, F. 1991. The restructuring of American public agricultural research and technology transfer system: implications for agricultural extension. In: Ricer, W.M. and Gustafson, D.J. (Eds), *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change.* Amsterdam, Elsevier Science, 43-56.

Buttel, F. 2001. Some reflections on later twentieth century agrarian political economy. *Sociologia Ruralis* 4 (2), 165-181.

Cabinet Office. 2002. *Farming and Food – a Sustainable Future*: Report of the Policy Commission on The Future of Farming and Food. London, The Cabinet Office.

Campbell, A. 2000. Fomenting synergy: experiences with facilitating Landcare in Australia. In: Roling, N.G. and Wagemaker, M.A.E. (Eds), *Facilitating Sustainable Agriculture* Cambridge, Cambridge University Press, 232-249.

Carberry, P.S. et al. 2002. The FARMSCAPE approach to decision support: farmers', advisers', researchers' monitoring, simulation, communication and performance indicators. *Agricultural Systems* 74 (1), 141-177.

Carver, M.F.F. 2000. Farmer funded agronomy –Arable Research Centres. *Journal of Royal Agricultural Society England* 161, 31-40.

CEAS Consultants (Wye) Ltd. 1991. *Conservation Advice to Farmers*. Report to the DoE, London.

Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. 2000 (Eds), *Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries*. Paris, INRA Editions.

Chambers, B.J., Davies, D.B. and Holmes, S. 1992. Monitoring of water erosion on arable farms in England and Wales, 1989-90. *Soil Use and Management* 8 (4), 163-170.

Chambers, B.J., Garwood, T.W.D. and Unwin, R.J. 2000. Controlling soil water erosion and P losses from arable land in England and Wales. *Journal of Environmental Quality* 29, 145-150.

Chambers, R. 1983. *Rural Development: Putting the Last First*. London, Longman.

Chambers, R. 1993. *Challenging the Professions: Frontiers for Rural Development*. London, Intermediate Technology Publications.

Chambers, R., Pacey, A. and Thrupp, L.A. 1989. (Eds), *Farmer First, Farmer Innovation and Agricultural Research*. London, Intermediate Technology Publications.

Checkland, P. 1981. *Systems Thinking, Systems Practice*. Chichester, Wiley.

Checkland, P. and Scholes, J. 1990. *Soft Systems Methodology in Action*. Chichester, Wiley.

Clark, J. and Lowe, P. 1992. Cleaning up agriculture: environment, technology and social science. *Sociologia Ruralis* 2 (1), 11-29.

Clark, G., Bowler, A., Shaw A., Crockett, A. and Ilbery, B. 1997. Institutions alternative farming systems and local reregulation. *Environment and Planning A* 29, 731-745.

Clark, J. and Murdoch, J. 1997. Local knowledge and the precarious extension of scientific networks: a reflection on three case studies. *Sociologia Ruralis* 37 (1), 38-60.

Clark, M.S., Horwarth W.R., Shennan C. and Scow, K.M. 1998. Changes in soil chemical properties resulting from organic and low-input farming practices. *Agronomy Journal,* 90, 662-671.

Clayden, B. and Hollis, J.M. 1984. Criteria for differentiating soil series. *Soil Survey Technical Monograph* 17, Harpenden, UK.

Cloke, P. 1997. Country backwater to virtual village? Rural studies and 'the cultural turn'. *Journal of Rural Studies* 13, 367-375.

Cobb, D., Dolman, P. and O'Riordan, T. 1999a. Interpretations of sustainable agriculture in the UK. *Progress in Human Geography,* 23 (2), 209-235.

Cobb, R. et al. 1999b. Integrating environmental and economic consequences of converting to organic agriculture: evidence from a case study. *Land Use Policy* 16, 207-221.

Coi. 1996. *Report on Evaluation of Code of Good Agricultural Practice for Soil.*

Commission of the European Communities (CEC). 1993. *Towards Sustainability.*

Commission of the European Communities (CEC). 1999. *Directions towards Sustainable Agriculture.*

Commission of the European Communities (CEC). 2001. Communication from the Commission to the Council, COM (2001) 264. http://europa.eu.int/comm/environment/soil/index.htm June 2001.

Commission of the European Communities (CEC). 2002. *Towards a Thematic Strategy for Soil Protection.* Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. COM (2002) 179, European Parliament 2003.

Contant, C.K. 1990. Providing information to farmers for groundwater quality protection. *Journal of Soil and Water Conservation* 45 (2), 314-7.

Cooper, N.K. 1999. *Street Level Bureaucrats and Agri-Environmental Schemes: The Case of the FRCA Project Officer Implementing ESA Schemes in England and Wales.* PhD Thesis, King's College, London.

Corcoran, K. and Dent, J.B. 1994. Education and extension: a perpetuating paradigm for success. In: Dent, J.B. and McGregor, M.J. (Eds), *Rural and Farming Systems Analysis European Perspectives.* CAB International, 255-268.

Coughenour, C.M. 2003. Innovating conservation agriculture: the case of no-till cropping. *Rural Sociology* 68 (2), 278-304.

Council of Europe. 1972, 1992. *A European Soil Charter.*

Council for the Protection of Rural England (CPRE). 1994. *Down to Earth - Environmental Problems Associated with Soil Degradation in the English Landscape.* Response from CPRE to Royal Commission on Environmental Pollution.

Council for the Protection of Rural England (CPRE). 1998a. Soil *the Essential Resource.*

Council for the Protection of Rural England (CPRE). 1998b. *A Charter for Soil.*

Council for the Protection of Rural England (CPRE). 2000. *Valuing Rural Land and Soil.* Submission to Rural England White Paper.

Countryside Council for Wales (CCW), English Nature, SNH and JNCC. 1994. *Problems Associated with Soils.* Combined evidence submitted to the Royal Commission on Environmental Pollution.

Country Landowners Association (CLA). 1995. Memorandum of evidence submitted to HLSCD. In: *Report from the Select Committee on SD.* Vol III. Written evidence. London, HMSO.

Coutts, J.A. 1995. Agricultural extension policy as a framework for change. *Journal of Agricultural Education and Extension* 2 (1), 17-28.

Cox, G., Lowe, P. and Winter, M. 1990. *The Voluntary Principle in Conservation: A Study of the Farming and Wildlife Advisory Group.* Chichester, Packard..

Craig, G.M. 1979. *Information Systems in UK Agriculture.* British Library R&D Report 5469. London, British Library.

Craig, G.M. 1995. *Agricultural and Rural Land-Use Information in the UK.* British Library R&D Report 6189. London, British Library.

Cranfield University. 2001. *A Guide to Better Soil Structure.* National Soil Resources Institute, Silsoe, Cranfield University.

Croix, N. and Hubert, B. 2000. Promoting collective learning in land use management project: a 13 year experience of researcher-technician partnership in the Cevenne (France) In: Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. (Eds), *Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries.* Paris, INRA Editions, 121-140.

Curry, N. 1997. Providing new environmental skills for British Farmers. *Journal of Environmental Management* 50, 211-222.

Curry, N. and Winter, M. 2000. The transition to environmental agriculture in Europe: learning processes and knowledge networks. *European Planning Studies*, 8 (1), 107-121.

Dampney, P.M.R., Lord E.I. and Chambers, B.J. 2000. Development of improved advice for farmers and advisers. *Soil Use and Management* 16, Supplement No 1, 162-166.

Dampney, P., Winter, W. and Jones, D. 2001. *Communication Methods to Persuade Agricultural Land Managers to Adopt Practices that will Benefit Environmental Protection and Conservation Management* (AgriComms). Report to DEFRA Farm Management Improvement Division.

Dancey, R.J. 1993. The evolution of agricultural extension in England and Wales. *Journal of Agricultural Economics.* 44 (3), 375-393.

Dauven, A., Crabb, J. and Johnson, P. 1998. *Nitrate Vulnerable Zones - Baseline Survey.* Report to RMED, MAFF.

Dauven, A. and Crabb, J. 1999. *Survey of Sugar Beet Growers' Information Needs.* Report to Sugar Beet Research and Education Fund.

Davies, B. and Finney, J.B. 2002. Reduced cultivations for cereals: research, development and advisory needs under changing economic circumstances. *HGCA Research Review* No. 48.

Dalton, G.E. 1980. The educational role of farm management extension work by state advisory services. *Journal of Agricultural Economics* 31 (2), 149-162.

DEFRA. 2002a. *The Strategy for Sustainable Farming and Food. Facing the Future.* London, DEFRA Publications.

DEFRA. 2002b. *Towards Sustainable Agriculture: A Pilot Set of Indicators.* London, DEFRA Publications.

DEFRA. 2002c. *Farm Practices Survey.* London, DEFRA Publications.

DEFRA. 2002d. *Agriculture and Environment R & D Newsletter.* 10, October. London, DEFRA Publications.

DEFRA 2002e *The Diffuse Water Pollution from Agriculture* Review 2002 http://www.defra.gov.uk/environment/water/dwpa/reports/dwpa01.htm; June 2003

DEFRA. 2003a. *Review of Rural Delivery.* Report by Lord Haskins. London, DEFRA Publications.

DEFRA. 2003b. *DEFRA: Our Strategy 2003-2006 Science and Innovation Strategy.* London, DEFRA Publications.

DEFRA. 2003c. *Overview of the Responses to the Draft Soil Strategy* www.defra.gov.uk/environment/consult/dss/response/pdf/soilresponse.pdf; September 2003.

DEFRA 2003d. *The Diffuse Water Pollution from Agriculture* Review 2003 http://www.defra.gov.uk/environment/water/dwpa/reports/dwpa07.htm; February 2004

DEFRA. 2004a. *First Soil Action Plan for England* 2004-06. DEFRA soil activities http://www.defra.gov.uk/environment/landliability/soil/index.htm#Research; June 2004.

DEFRA. 2004b. *Consultation Document on Proposed and Possible Measures of Implementation of Cross Compliance in England* www.defra.gov.uk/corporate/consult/current.htm; April 2004.

DEFRA 2004c. *Mapping the Problem. Risks of Diffuse Water Pollution from Agriculture.* DEFRA Publications, London

DEFRA. 2004d. *Strategic Review of Diffuse Water Pollution from Agriculture. Initial Appraisal of Policy Instruments to Control Water Pollution from Agriculture.* DEFRA Publications, London

DEFRA. 2004e. *Developing Measures to Promote Catchment-Sensitive Farming.* A joint DEFRA-HM Treasury Consultation. DEFRA Publications, London.

DEFRA. 2004f. *Rural Strategy.* London, DEFRA Publications.

DEFRA and HGCA. 2002. *Arable Cropping and the Environment. A Guide.* London, DEFRA Publications.

Denscombe, M. 1998. *The Good Research Guide: for Small-scale Social Research Projects.* Milton Keynes, Open University Press.

Denzin, N.K. 1970. *The Research Act in Sociology.* Chicago, Aldine.

DETR. 1997. *Sustainable Use of Soils.* Government Response to Royal Commission on Environmental Pollution.

DETR. 1998a. *Environmental Effects of Agriculture.*

DETR. 1998b. *Draft National Soil Strategy.*

DETR. 1999. *A Better Quality of Life – a Strategy for Sustainable Development for the UK.*

DETR. 2001. *Draft Soil Strategy for England– a Consultation Paper.*

Dexter, K. 1983. *Extension Services, Agribusiness Firms and Marketing Organisations.* Paper prepared for the Seminar on Diffusion of Knowledge and Extension, Paris, France.

Dighton, J. and Jones, H.E. 1994. *A Review of Soil Biodiversity.* A Report to the Royal Commission on Environmental Pollution. ITE, Grange- over-Sands, Cumbria.

Dissanayake, W. 1986. In: Beal G. M., Dissanayake, W. and Konoshima, S. (Eds), *Knowledge Generation, Exchange and Utilisation.* Boulder, Westview Press, 135-150.

Dissanayake, W. 1992. Knowledge culture and power: some theoretical issues related to the agricultural knowledge and information systems framework. *Knowledge and Policy; the International Journal of Knowledge Transfer and Utilisation* 5 (1) 65-76.

DoE. 1994. *Sustainable Development - The UK Strategy.* HMSO, London.

Doran, J.W. 2001. Soil health and global sustainability: translating science into practice. *Agriculture, Ecosystems and Environment* 88 (2), 119-127.

Doran, J.W. and Safley, A. 1997. Defining and assessing soil health and sustainable productivity. In: Pankhurst, C., Doube, B. M., Gupta, V.V.S.R. (Eds), *Biological Indicators of Soil Health.* Wallingford, CAB International, 1-28.

Drew Associates. 2003. *Audit of UK Soil Research.* Final Report SP0524 for DEFRA, Drew Associates, Wiltshire, UK.

Drummond, C.J. 2000. EMS in practice: the experiences of LEAF in meeting the needs of farmers, consumers and environmentalists. In: Farming Systems for the New Millennium, Association of Applied Biologists. *Aspects of Applied Biology* 62. December 2000, 165-172.

Dudal, R. 1981. An evaluation of conservation needs. In: Morgan R.P.C. (Ed), *Soil Conservation, Problems and Prospects.* Chichester, Wiley, 3-12.

Dwyer, J., Eaton, R., Farmer, A., Baldock, D., Withers, P. and Silcock, P. 2002. *Policy Mechanisms for the Control of Diffuse Agricultural Pollution, with Particular Reference to Grant Aid.* English Nature Research Report No. 455.

Dwyer, J. and Buller, H. 2004. *Making the CAP fit for Herefordshire.* Background paper presented at conference. Making the CAP fit for Herefordshire. January 2004.

Earle, T.R., Rose, C.W. and Brownlea, A.A. 1979. Socio-economic predictors of intention towards soil conservation and their limitation in environmental management. *Journal of Environmental Management* 9, 225-236.

ECOTEC. 2000. *Economic Evaluation of Free Advice Programmes on Conservation, Pollution Abatement and Conversion to Organic Farming.* Report C1752 to MAFF.

Eldon, J. 1988. Agricultural change, conservation, and the role of advisers. *ECOS* 9 (4), 15-20.

Engel, P.G.H. 1990. Knowledge management in agriculture: building upon diversity. *Knowledge in Society* 3 (3), 28-35.

Engel, P.G.H. 1997. *The Social Organisation of Innovation. A Focus on Stakeholder Interaction*. Amsterdam, KIT Publishers.

Environment Agency. 2000. *Aquatic Eutrophication in England and Wales: a Management Strategy.*

Environment Agency. 2001. *Best Farming Practices: Profiting from a Good Environment* R&D Publication 23.

Environment Agency. no date. *Diffuse Pollution from Agriculture. A Field Guide* R&D Publication No 13.

Environment Agency. no date. *Understanding Buffer Strips*. Information booklet.

Environment Agency. 2004a. *Soil, the Hidden Resource. Towards an Environment Agency Strategy for Soil Protection, Management and Restoration - a consultation document.*

Environment Agency. 2004b. *The State of Soils in England and Wales.*

European Commission. 2001. *The CAP Reform. A Policy for the Future.* Directorate General of Agriculture Fact Sheet http://europa.eu.int/comm/agriculture/publi/fact/policy/en.pdf; June 2003.

European Conservation Agriculture Federation (ECAF). no date. *Conservation Agriculture in Europe: Environmental, Economic and EU Policy Perspectives*. Brussels ECAF.

European Environment Agency (EAA). 1995. *Europe's Environment: The Dobris Assessment*. Copenhagen, European Environment Agency.

European Environment Agency (EAA). 2000a. Down to earth: soil degradation and sustainable development in Europe. *Environmental Issues Series* No 16. Copenhagen, European Environment Agency.

European Environment Agency (EAA). 2000b. *Europe's Environment: The Second Assessment.* Copenhagen, European Environment Agency.

European Environment Agency (EAA). 2003. *Europe's Environment: the Third Assessment.* Copenhagen, European Environment Agency.

European Fertilizer Manufacturers Association (EFMA) no date. *Sustainable Soil Management - an Achievable Goal.* EFMA, Brussels.

European Union. 2003. Press Release http://europa.eu. int/comm/environment/soil/index.htm; February 2003.

Evans, R. 1990a. Soils at risk of accelerated erosion in England and Wales. *Soil Use and Management*, 6 (3), 125-131.

Evans, R. 1990b. Water erosion in British farmers' fields - some causes, impacts, predictions. *Progress in Physical Geography*, 14(2), 199-219.

Fairhead, J. and Scoones, I. (in press). Local knowledge and the social shaping of soil investments: critical perspectives on the assessment of soil degradation in Africa. *Land Use Policy.*

Farmers Weekly. 2002. Mud case farmer faces more action. *Farmers Weekly* 11 February 2002. Farmers Weekly Interactive. www.fwi.co.uk/live/; June 2002

Farmers Weekly. 2003. Experts offer new service. *Farmers Weekly* 16 January 2003. Farmers Weekly Interactive. www.fwi.co.uk/live/; June 2003

Farmers Weekly. 2004a. Soil help needed to keep SFP. *Farmers Weekly* 13 May 2004. Farmers Weekly Interactive. www.fwi.co.uk/live/; June 2004

Farmers Weekly. 2004b. Certificate to suss soil. *Farmers Weekly* 15 June 2004. Farmers Weekly Interactive. www.fwi.co.uk/live/; June 2004

Faeth, P. 1993. *Agricultural Policy and Sustainability.* World Resources Institute, Washington, D.C.

FAO. 1981. *World Soil Charter.*

Fearne, A. 1991. Agricultural information: a farmer's point of view. In: Kuiper, D. and Roling, N.G. (Eds), *European Seminar on Knowledge Management and Information Technology.*

Fearne, A. and Ritson, C. 1989. *Communications in Agriculture.* University of Newcastle upon Tyne. Dept Agricultural Economics and Food Marketing.

Feather, P.M. and Amacher, G.S. 1994. Role of information in the adoption of best management practices for water quality improvement *Agricultural Economics* 11, 159-170.

Fell, O.R. 2000. Time to converse: the importance of language, conversation and electronic media in agricultural extension. *Australian Journal of Experimental Agriculture* 40, 503-509.

Fell, L. and Russell, D.B. 2000. The human aspects for understanding and agreement. In: Ison, R.L and Russell, D.B. (Eds), *Agricultural Extension and Rural Development. Breaking the Traditions.* Cambridge, Cambridge University Press, 32-51.

Fielding, C. 1993. Coding and managing data. In: Gilbert, N. (Ed), *Researching Social Life* . London, Sage Publications.

Fink, A. 1995. *How to Sample in Surveys.* The Survey Kit TSK 6. London, Sage Publications.

Foster, I.D.L., Harrison, S. and Clark, D. 1997. Soil erosion in the West Midlands: an act of God or agricultural mismanagement? *Geography*, 82 (3), 231-239.

Friends of the Earth (FoE). 1996. *Soil Erosion and its Impact in England and Wales.* London, Friends of the Earth.

Garcia-Torres, L., Benites, J. and Martinez-Vilela, A. 2001 (Eds), *Conservation Agriculture. A World-wide Challenge* Volume 1.

Garforth, C. and Usher, R. 1997. Promotion and uptake pathways for research output: a review of analytical frameworks and communication channels. *Agricultural Systems* 55 (2), 301-322.

Garforth, C., Angell, B., Archer, J. and Green, K. 2002. *Improving Access to Advice for Land Managers: a Literature Review of Recent Developments in Extension and Advisory services.* Report to the Department for Environment, Food and Rural Affairs by the School of Agriculture, Policy and Development at The University of Reading, ADAS Consulting Ltd and John Archer Consulting.

Garforth, C., Angell, B. and Archer, J. 2003. Fragmentation or creative diversity? Options in the provision of land management advisory services. *Land Use Policy* 20 (4), 323-333.

Gasson, R. and Hill, B. 1996. *Socio-economic Determinants of the Level and Rate of On-farm Innovation.* Vol.1. A review of literature. Vol.2. Mechanisms of technology transfer in agriculture and horticulture. Wye College, UK.

Giddens, A. 1987. *Social Theory and Modern Sociology.* Cambridge, Cambridge University Press.

Giles A.K. 1983. Some human aspects of giving and taking farm management advice. *Journal of Agricultural Economics* 34, 317-327.

Glastonbury, B. and Mackean, J. 1991. In: Allan, G. and Skinner, C. (Eds), *Handbook for Research Students in Social Sciences.* London, The Falmer Press.

Global Assessment of Soil Degradation (GLASOD). 1990. *World Map of the Status of Human-induced Soil Degradation.* United Nations Environment Programme and International Soil Reference and Information Centre Winand Staring Centre, Wageningen, the Netherlands.

Gordon J.E., Gubbins, N, Taylor, A.G. and McKirdy, A.P. 1996. In: Taylor, A.G., Gordon, J.E. and Usher, M.B. 1996 (Eds), *Soils, Sustainability and the Natural Heritage.* HMSO, Edinburgh, 7-21.

Gray, I., Dunn, T. and Phillips, E. 1997. Power, interests and extension of sustainable agriculture. *Sociolgia Ruralis* 37 (1), 97-113.

Hakim, C. 1987. *Research Design: Strategies and Choices in the Design of Social Research.* London, Allen and Unwin.

Hamel, J. et al. 1993. Case Study Methods. *Qualitative Research Methods,* Vol. 32. Thousand Oaks, CA, Sage Publications.

Harrington, G. 1997. *Technology Transfer in the Livestock and Meat Industry.* Commissioned Report to the Research Steering Committees of MLC.

Harter, D. and Hass, G. 1992. Commercialisation of British extension systems. Promise or primrose path? *Journal of Extension Systems* 8, 37-44.

Hassanein, N. 1999. *Changing the Way America Farms: Knowledge and Community in the Sustainable Agriculture Movement.* Lincoln and London. University of Nebraska Press.

Hassanein, N. and Kloppenburg, J.R. Jr. 1995. Where the grass grows again: knowledge exchange in the sustainable agriculture movement. *Rural Sociology* 60 (4), 721-740.

Hatcheul, A. 1997. Coordination and control. In: Sorge, A. and Warmer, M. (Eds), *Handbook of Organisational Behaviour*. London, Thomson Publishers..

Havelock, R.G. 1986. Linkage: key to understanding the knowledge systems. In: Beal, G.M., Dissanayake, W. and Konoshima, S. (Eds), *Knowledge Generation, Exchange and Utilisation*. Boulder, Westview Press, 11-37 and 211-245.

Hawkins, E. 1991. *Changing Technologies: Negotiating Autonomy on Cheshire Farms*. Unpublished PhD thesis, South Bank Polytechnic, London.

Hemidy, L. and Cerf, M. 2000. Managing change in advisory services: controlling the dynamics of resource transformation and use. In: Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. (Eds), *Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries*. Paris, INRA Editions, 351-368.

Hindress, B. 1986. Actors and social relations. In: Wardell, M. and Turner, S. (Eds), *Sociological Theory in Transition*. London, Allen and Unwin.

Home Grown Cereal Authority (HGCA). 2000. *Research Strategy*. www.hgca.co.uk; June 2003

Howard, P.J.A. and Hornung, M. 1989. *An Assessment of the Principles of the Soil Protection in the UK*. Volume I Concepts and Principles, ITE, NERC.

Ilbery, B.W. 1978. Agricultural decision making: a behavioural perspective. *Progress in Human Geography* 2, 448-66.

Ison, R.L. 2000. Experience, tradition and service. Institutional R&D in the rangelands. In: Ison, R.L. and Russell, D.B. (Eds), *Agricultural Extension and Rural Development. Breaking the Traditions*. Cambridge, Cambridge University Press, 103-132.

Ison, R.L and Russell, D.B. 2000. *Agricultural Extension and Rural Development. Breaking the Traditions*. Cambridge, Cambridge University Press.

Ison, R.L., High, C., Blackmore, C.P. and Cerf, M. 2000. Theoretical frameworks for learning based approaches to change in industrialised country agricultures. In: Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. (Eds), *Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries*. Paris, INRA Editions, 31-53.

Joint Nature Conservation Council (JNCC). 2002. *Environmental Effects of the CAP and Possible Mitigation Measures*. Report to DEFRA.

Jones, G.E., Rolls, M.J., and Tranter, R.B. (1987). *Information Management in Agriculture* British Library Review and Report 5931. London, British Library.

Jones, G.E. and Garforth, C. 1997. The History, Development, and Future of Agricultural Extension. In: Swanson, B.E. (Ed), *Agricultural Extension: a Reference Manual*. Rome, Food and Agricultural Organization of the United Nations, 3-12.

Jordan, V.W.L., Hutcheon, J.A., Donaldson, C.V. and Farmer, D.P. 1997. Research into and development of integrated farming systems for less intensive arable crop production: experimental progress 1989-1994 and commercial implementation. *Agriculture, Ecosystems and Environment* 64, 141-148.

Jordan, V.W.L., Leake, A.R. and Ogilvy, S. 2000. Agronomic and environmental implications of soil management practices in Integrated Farming Systems. In: Farming Systems for the new Millennium, Association of Applied Biologists *Aspects of Applied Biology* 62. December 2000, 61-67.

Jordan, V.W.L. 2001. UK: the Less Intensive Farming and Environment project (LIFE) In: *Review of ICM systems in the EU: Guidelines for Stage* III. Brussels, DG Environment.

Juntti, M. and Potter, C. 2002. Interpreting and reinterpreting agri-environmental policy: communication, trust and knowledge in the implementation process. *Sociologia Ruralis* 42 (3), 215-232.

Kabourakis, E. 2000. Learning processes in designing and disseminating ecological olive production systems in Crete Greece In: Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. (Eds), *Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries*. Paris, INRA Editions, 97-110.

Kaimowitz, D. (Ed). 1990. *Making the Link Agricultural Research and Technology in Developing Countries*. Special Studies in Agricultural Science and Technology. Boulder, Westview Press, 1-42.

Kersten, S. 2000. From debate about degradation to dialogue about vegetation management in Western Australia. In: Roling, N.G. and Wagemaker, M.A.E.

2000. (Eds.), *Facilitating Sustainable Agriculture.* Cambridge, Cambridge University Press, 172-190.

Kersten, S. and Ison, R. 1999. Listening, interpretative cycles and dialogue: process design for collaborative research and development. *Journal of Agricultural Education and Extension* 5 (3), 163-177.

Kidd, A.D., Lamers, J.P.A., Ficarelli, P.P. and Hoffmann, V. 2000. Privatising agricultural extension: caveat emptor. *Journal of Rural Studies* 16 (1), 95-102.

Kitchen, R. and Tate, N. J. 2000 *Conducting Research into Human Geography.* Englewood Cliffs, N.J., Prentice Hall.

Kloppenburg, J., Jr. 1991. Social theory and the de/reconstruction of agricultural science: local knowledge for and alternative agriculture. *Rural Sociology* 56 (4) 519-548.

Knorr-Cetina, K. D. 1981. *The Manufacture of Knowledge: an Essay on the Constructivist and Contextual Nature of Science.* Oxford, Pergamon Press.

Kolb, D.A. 1984. *Experiential Learning.* Englewood Cliffs, N.J., Prentice Hall.

Koutsouris, A. and Papdopoulos, D. 2000. Extension functions and farmers attitudes in Greece. In: Roling, N.G. and Wagemaker, M.A.E. (Eds), *Facilitating Sustainable Agriculture* Cambridge, Cambridge University Press, 88-101.

Kuhn, T. 1970. *The Structure of Scientific Revolutions.* Chicago, Chicago University Press.

Latour, B. 1987. *Science in Action: How to Follow Scientists and Engineers through Society.* Milton Keynes, Open University Press.

Law, J. (Ed). 1986. *Power, Action and Belief. A New Sociology of Knowledge?* Boston and Henley, Routledge and Kegan Paul.

Leake, A. 2001. UK: Focus on Farming Practice (FOFP) In: *Review of ICM systems in the EU: Guidelines for Stage III.* Brussels, *DG Environment.*

Leeuwis, C. 1993a. On computers, myths and modelling. *Wageningen Studies in Sociology* 36. Wageningen, The Agricultural University, Pudoc.

Leeuwis, C. 1993b. Towards a sociological conceptualisation of communication in extension science. *Sociologia Ruralis* 33 (2), 281-305.

Leeuwis, C. 2000. Learning to be sustainable. Does the Dutch agrarian knowledge market fail? *Journal of Agricultural Education and Extension* 7 (2) 79-92.

Leeuwis, C., Long, N. and Villarreal, M. 1991. Equivocations on knowledge systems theory: an actor oriented critique. In: Kuiper, D. and Roling, N.G. (Eds), *The Edited Proceedings of the European Seminar on Knowledge Management and Information Technology*. Wageningen, The Agricultural University, 21-29.

Legg, W. 2000. *Sustainable Agriculture: an Economic Perspective from the OECD Conference in the UK on Sustainable Agriculture*. www.oecd.org/agr/News/; October 2002.

Lichtenberg, E. and Zimmerman, R. 1999. Information and farmers attitudes about pesticides, water quality and related environmental effects. *Agriculture, Ecosystem and Environment* 73 (3), 227-236.

Liebig, M.A. and Doran, J.W. 1999. Evaluation of farmers' perceptions of soil quality indicators. *American Journal of Alternative Agriculture* 14 (1), 11-21.

Lionberger, H.F. and Chang, C. 1970. *Farm Information for Modernising Agriculture: the Taiwan System*. New York, Praeger Press.

Little, J. 1999. Otherness, representation and the cultural construction of rurality. *Progess in Human Geography* 23(3), 437-442.

Long, N. (Ed). 1989. Encounters at the interface. A perspective on social discontinues in rural development. *Wageningen Studies in Sociology* 27. Wageningen, the Agricultural University, Pudoc.

Long, N. 1992. From paradigm lost to paradigm regained. The case of actor-oriented sociology of development. In: Long, N. and Long, A. (Eds), *Battlefields of Knowledge: the Interlocking Theory and Practice of Social Research and Development*. London, Routledge, 16-43.

Long, N. 2001. *Development Sociology. Actor Perspectives*. London, Routledge.

Long, N. and van der Ploeg, J.D. 1989. Demythologizing planned intervention. *Sociologia Ruralis* 29, 227-249.

Long, N. and van der Ploeg, J.D. 1994. Heterogeneity actor and structure: towards reconstitution of the concept of structure. In: Booth, D. (Ed), *Rethinking Social Development Theory, Research and Practice*. Harlow, UK, Longman Scientific and Technical, 62-89.

Long, N. and Villarreal, M. 1994. The interweaving of knowledge and power in development interfaces. In: Scoones, I. and Thompson, J. (Eds), *Beyond*

Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice. London, Intermediate Technology.

Lowe, P. (Ed). 1992. Industrial agriculture and environmental regulation. *Sociolgia Ruralis* 32 (1), 1-188.

Lowe, P., Clark, J., Seymour, S. and Ward, N. 1994. Officials, advisors and farmers: the local construction of agricultural pollution and its regulation. In: van der Ploeg, J. D. et al. (Eds), *On the Impact of Endogenous Development in Rural Areas*, Vol II European Commission, Conference Proceedings.

Lowe, P., Clark, J., Seymour, S. and Ward, N. 1997. *Moralising the Evironment: Countryside Changes, Farming and Pollution*. London, UCL Press.

Lundberg, C.C. 1997. Towards general model of consultancy: foundations. *Journal of Organisational Change Management* 10 (3), 193-200.

Lundvall, B. and Johnson, B. 1994. The Learning Economy. *Journal of Industry Studies* 1 (2), 23-42.

Lyon, F. 1996. How farmers research and learn: the case of arable farmers of East Anglia, UK. *Agriculture and Human Values* 13 (4), 39-47.

MacRae, R.J., Hill, S.B., Hening, J. and Mehuys, G.R. 1989. Agricultural Science and sustainable agriculture: a review of the existing scientific barriers to sustainable food production and potential solutions. *Biological Agriculture and Horticulture* 6, 173-219.

MAFF. 1970. *Modern Farming and the Soil*. Report of the Agricultural Advisory Council on Soil Structure and Soil Fertility. London, HMSO.

MAFF. 1996. *Research Strategy*. London, MAFF Publications.

MAFF. 1997. *Environmental Protection Newsletter* 1 January 1997, London, MAFF Publications.

MAFF. 1998a. *Environmental Indicators of Sustainable Agriculture*. London, MAFF Publications.

MAFF. 1998b. *Code of Good Agricultural Practice for the Protection of Soil*. London, MAFF Publications.

MAFF. 1998c. *Environmental Protection R&D Newsletter*. London, MAFF Publications.

MAFF. 1999a. *Controlling Soil Erosion by Water: a Manual for the Assessment of Agricultural Land at Risk of Water Erosion on Lowland England*. London, MAFF Publications.

MAFF. 1999b. *Controlling Soil Erosion by Water: a Field Guide for an Erosion Risk Assessment for Farmers and Consultants*. London, MAFF Publications.

MAFF. 1999c. *Tackling the Nitrate from Agriculture. Strategy from Science*. London, MAFF Publications.

MAFF. 2000a. *Towards Sustainable Agriculture: A Pilot Set of Indicators*. London, MAFF Publications.

MAFF. 2000b. *Research Strategy 2001-2005*. Consultation document. London, MAFF Publications.

MAFF. 2000c. *Review of Salmon and Freshwater Fisheries: Agricultural Pollution*. London, MAFF Publications.

MAFF. 2000d. *Fertiliser Recommendations for Arable and Horticultural Crops*, RB209. Revised 2000, London, MAFF Publications.

MAFF. 2001a. *Register of Agri-Environmental R&D* 1999/2000 update. London, MAFF.

MAFF. 2001b. *Better Regulation Task Force: Report on Environmental Regulations and Farmers*. Government Response. Report (Haskins) for MAFF and DETR.

Marsden, T., Munton, R., Whatmore, S. and Little, J. 1986. Towards a political economy of capitalist agriculture: a British perspective. *International Journal of urban and regional research* 19, 498-521.

Marsden, T. J. et al. 1993. *Constructing the Countryside*. London, University College Press.

Marshall, E. J. P. 2002. *Environmental Information for Agronomists 2002: Needs and Provision*. A report by the Farmed Environment Company for Crop Protection Association UK Ltd and UKASTA.

Maturana, H. R. and Varela, F. J. 1987. *The Tree of Knowledge: the Biological Roots of Understanding*. Boston (Mass.), Shambala Publications.

May, T. 1997. *Social Research Issues Methods and Process*. Milton Keynes, Oxford University Press.

McCorkle, C. M. 1989. Towards a knowledge of local knowledge and its importance for agricultural R&D. *Agriculture and Human Values* 6 (3), 4-12.

McCown, R.L. 2001. Learning to bridge the gap between science-based decision support and the practice of farming: Evolution in paradigms of model-based research and intervention from design to dialogue. *Australian Journal of Agricultural Research* 52 (5), 549-572.

McCown, R.L. 2002. Changing systems for supporting farmers' decisions: problems, paradigms, prospects. *Agricultural Systems* 74 (1), 179-220.

McDermott, J.K. 1987. Making extension effective: the role of extension research linkages. In: Rivera, W., Schram, S. (Eds), *Agricultural Extension Worldwide*. New York, Croom Helm.

McEachern, C. 1992. Farmers and conservation: conflict and accommodation in farming politics. *Journal of Rural Studies* 8 (20), 159-171.

McGrath, S. 1993. Soil quality in relation to agricultural use In: Eustackers, H. J. P. and Hamers, T. (Eds), *Integrated Soils and Sediment Research: a Basis for Proper Protection*. Dordrecht, Kluwer.

McGrath, S.P. 1994. Effects of heavy metals from sewage sludge on soil microbes in agricultural systems. In: Ross, S.M. (Ed), *Toxic Metals in Soil-Plant Systems*. Chichester, Wiley, 247-74.

McHenry, H. 1997. Wild flowers in the wrong field are weeds! Examining farmers' constructions of conservation. *Environment and Planning A*, 29,1039-1053.

Miller, D.R. and Rossman, A.Y. 1997. Biodiversity and systematic: their application to agriculture. In: Reaka-Kudla, M.L., Wilson, D.E. and Wilson, E.D. (Eds), *Biodiversity II Understanding and Protecting our Biological Resources*. Washington D.C., Joseph Henry Press.

Molnar, J.J., Duffy, P.A., Cummins, K.A., Vam Santen, E. 1992. Agricultural science and agricultural counterculture: paradigms in search of a future. *Rural Sociology* 57 (1), 83-91.

Moore, J.C. et. al. 1995. Soil biodiversity: a literature review. *Scottish Natural Heritage Review* No 17.

Morgan, K. and Murdoch, J. 2000. Organic vs. conventional agriculture: knowledge, power and innovation in the food chain. *Geoforum* 31, 159-173.

Morris, C. and Potter, C. 1995. Recruiting the new conservationists: farmer adoption of agri-environmental schemes in the UK. *Journal of Rural Studies* 11 (1), 51-63.

Morris, C. and Winter, M. 1999. Integrated farming systems: the third way for European agriculture? *Land Use Policy* 16, 193-205.

Morris, C. and Evans, N. 2004. Agricultural turns, geographical turns: retrospect and prospect. *Journal of Rural Studies* 20 (1), 95-111.

Morris, J., Mills, J. and Crawford, I.M. 2000. Promoting uptake of agri-environmental schemes: the Countryside Stewardship Arable Options Schemes. *Land Use Policy* 17, 241-254.

Murdoch, J. 1994. *Weaving the Seamless Web: a Consideration of Network Analysis and its Potential Application to the Study of the Rural Economy.* Centre for Rural Economy Working Paper 3, Newcastle.

Murdoch, J. 1997. Inhuman/nonhuman/human: actor network theory and the prospects for a non dualistic and symmetrical perspective on nature and society. *Environment and Planning D: Society and Space* 15, 731-56.

Murdoch, J. 2000. Networks – a new paradigm of rural development? *Journal of Rural Studies* 16 (4), 407-419.

Murdoch, J. and Clark, J. 1994. Sustainable knowledge. *Geoforum* 25 (2), 115-132.

Napier, T.L., Thraen, C.S., Gore, A. and Goe, W.R. 1984. Factors affecting the adoption of conventional and conservation tillage practices in Ohio. *Journal of Soil and Water Conservation*, May-June, 201-209.

Nagel, U.L.J. 1980. Institutionalization of knowledge flows. *Quarterly Journal of International Agriculture* 30 Special Issue.

National Audit Office (NAO). 1991. *Advisory Services to Agriculture.* Report by the Controller and Auditor General. London, HMSO.

National Trust. 1996. *Draft Soil Protection Policy* (internal document).

National Trust. 2002. *Soils, Water and Nutrients: Management and Conservation in Agricultural Landscapes* (internal document).

Needham, P. 1998. Privatising an extension service. In: Wallace, I. (Ed), *Rural Knowledge Systems for the 21st Century* AERDD, ADAS, SAC Proceedings, 192-198.

Neetson, J. 1995. Soil management and conservation. *Outlook on Agriculture* 23,3-4.

Neuman, W.L. 1991 *Social Research Methods.* USA, Allyn and Bacon.

NERC. 1994. *NERC Evidence to the Royal Commission on Environmental Pollution Study: Environmental Problems Associated with Soil.*

National Farmers' Union (NFU). 1994. *Submission by National Farmers' Union of England Wales to Royal Commission on Environmental Pollution: Study on Environmental Problems with Soil.*

National Farmers' Union. 1995. *Taking Real Choices Forward.* March 1995.

Nilsson, E. and Wallace, I. 1998. Is consultancy the same as extension? In: Wallace, I. (Ed), *Rural Knowledge Systems for the 21st Century* AERDD, ADAS, SAC Proceedings, 108-110.

Norgaard, R. 1984. Traditional agricultural knowledge: past performance, future prospects and institutional implications. *American Agricultural Economics Association* 66, 874-878.

Nowak, P.J. 1987. The adoption of agricultural conservation technologies: economic and diffusion explanations. *Rural Sociology* 52 (2), 208-220.

Nowak, P.J. and Korsching, P.F. 1998. The human dimension of soil and water conservation: A Historical and methodological perspective. In: Pierce, F.J. and Frye, W.W. (Eds), *Advances in Soil and Water Conservation.* Chelsea MI, Ann Arbor Press, 159-184.

Oberle, S. 1994. Farming systems options for US agriculture. An agroecological perspective. *Journal of Productive Agriculture* 7, 119-123.

O'Riordan. 1993. *Towards a Sustainable Agriculture in the UK.* Proceedings 344 Peterborough, The Fertiliser Society.

Organisation for Economic Co-operation and Development (OECD) 1992. *Current Status of Different Forms of Funding Agricultural Advisory Services in OECD Countries* Conference of Directors of Agricultural Advisory Services. (unpublished).

Organisation for Economic Co-operation and Development (OECD). 1997. *Environmental Indicators for Agriculture.*

Organisation for Economic Co-operation and Development (OECD). 2000. *Agricultural Knowledge Systems Addressing Food Safety and Environmental Issues.* Conference Summary Report.

Organisation for Economic Co-operation and Development (OECD). 2001. *Adoption of Technologies for Sustainable Farming Systems.* Workshop Proceedings Wageningen, The Agricultural University.

Padel, S. 1884. *Adoption of Organic Farming as an Example of the Diffusion of an Innovation.* Centre for Organic Husbandry and Agroecology Discussion Paper Series 94/1, University of Wales, Aberystwyth.

Papy, F. 1994. Working knowledge concerning technical systems and decision support. In: Dent, J.B. and McGregor, M.J. (Eds), *Rural and Farming Systems Analysis European Perspectives.* CAB International, 222-235.

Parfitt, J. 1997. Questionnaire design. In: Flowerdew, R. and Martin, M. (Eds), *Methods in Human Geography.* Harlow, Longman.

Park, J. et. al. 1997. Integrated arable farming systems and their potential uptake in the UK *Farm Management* 9 (10), 483-494.

Parker, C. 1999. *Bridging the Gap: User Centred Design and Support Methods for Decision Support Systems in Crop Production.* PhD thesis, Loughborough University.

Parker, C. and Campion, S. 1997. Improving the uptake decision support systems in agriculture. In: *Proceedings of the First European Conference for Information Technology in Agriculture Copenhagen*, 15-81 June 1997, 129-134.

Parker, C. and Sinclair, M. 2001. User-centred design does make a difference. The case of decision support systems in crop production. *Behaviour and Information Technology* 20 (6), 449-460.

Pearce, D., Markandya, A. and Barbier, E.B. 1989. *Blueprint for a Green Economy.* London, Earthscan.

Petrzelka, P., Padgitt, S. and Connelly, K. 1997. Teaching old dogs survival tricks: a case study in promoting integrated crop management. *Journal of Productive Agriculture* 10 (3), 596-602.

Pieda plc. 1992. *Conservation Advice to Farmers.* Report for DoE, London.

Pierce, J.T. 1993. Agriculture sustainability and the imperatives of policy reform. *Geoforum* 24, 381-96.

Plotkin, H. 1994. *The Nature of Knowledge.* London, The Penguin Press.

Polanyi, M. 1966. *The Tacit Dimension.* London, Routledge.

Portela, J. 1994. Agriculture: Is the Art de la Localite back? The role and function of indigenous knowledge in rural communities. In: Dent, J.B. and McGregor, M.J. (Eds), *Rural and Farming Systems Analysis European Perspectives.* CAB International, 269-278.

Powlson, D.S. 2000. Tackling nitrate from agriculture. *Soil Use and Management* 16, Supplement No 1, 141-141.

Pretty, J. 1995. *Regenerating Agriculture: Policies and Practice for Sustainability and Self-reliance*. London, Earthscan.

Punch, K.F. 1998. *Introduction to Social Research: Quantitative and Qualitative Approaches*. London, Sage Publications.

Ramkumar, S.N. 1994. *The Analysis of Farmer Information Systems for Feeding Dairy Cattle in Two Villages of Kerala State, India*. Unpublished PhD thesis, University of Reading.

Ramkumar, S.N. and Rolls, M.J. 1995. *Research on Agricultural Information Systems: a Guide to Terminology and Concepts*. Working Paper 95/7, AERDD, University of Reading.

Royal Agricultural Society of England (RASE). 2000. *Response to Government Consultation Document 'Development of a Set of Indicators for Sustainable Agriculture in the United Kingdom'*. Stoneleigh, Royal Agricultural Society of England.

Royal Commission on Environmental Pollution (RCEP). 1996. *Sustainable Use of Soil.* RCEP Nineteenth Report. London, HMSO.

Reganold, J.P. 1995. Soil quality and farm profitability studies of biodynamic and conventional farming systems. In: Cook, H.F. and Lee, H.C. (Eds), *Soil Management in Sustainable Agriculture.* Ashford, Wye College Press, 1-11.

Richards, P. 1985. *Indigenous Agricultural Revolution*. London, Hutchinson.

Richards, P. 1993. Cultivation: knowledge or performance? In: Hobart, M. (Ed), *An Anthropological Critique of Development: the Growth of Ignorance*. London, Routledge, 61-78.

Riley, M. N. 1963. *Sociological Research. A Case Study Approach.* Harcourt, Brace and World.

Rivera, W.M. 1997. Agricultural extension into the next decade. *European Journal of Agricultural Education and Extension* 4 (1), 29-38.

Rivera, W.M. 2000. The changing nature of agricultural information and the conflictive global developments shaping extension. *Journal of Agricultural Education and Extension* 7 (1), 31-41.

Robson, C. 1993. *Real World Research*. Oxford, Blackwell.

Rogers, E.M. 1983. *Diffusion of Innovations* 3th Ed. New York, Free Press.

Rogers, E.M. 1986. Models of knowledge transfer: critical perspectives. In: Beal, G.M., Dissanayake, W. and Konoshima, S. (Eds), *Knowledge Generation, Exchange and Utilisation*. Boulder, Westview Press, 37-61.

Rogers, E.M. 1995. *Diffusion of Innovations* 4th Ed. New York, Free Press.

Roling, N. 1985. Extension science: increasingly preoccupied with knowledge systems. *Sociological Ruralis* 25(3/4), 269-290.

Roling, N. 1988. *Extension Science. Information Systems in Agricultural Development*. Cambridge, Cambridge University Press.

Roling, N. 1990. The agricultural research-technology transfer interface: a knowledge systems perspective. In: Kaimowitz, D. (Ed), *Making the Link. Agricultural Research and Technology in Developing Countries.* Special Studies in Agricultural Science and Technology. Boulder, Westview Press, 1-42.

Roling, N. 1992. The emergence of knowledge systems thinking: a changing perception of relationships among innovation, knowledge process and configuration. *Knowledge and Policy* 5 (1), 42-64.

Roling, N. 1993. Agricultural knowledge and environmental regulation in the Netherlands. A case study of the crop protection plan. *Sociolgia Ruralis* 33 (2), 261-280.

Roling, N. 1994. Interaction between extension sources and farmer decision making. New issues and sustainable farming. In: Dent, J.B. and McGregor, M.J. (Eds), *Rural and Farming Systems Analysis European Perspectives.* CAB International, 280-291.

Roling, N. 1998. The changing information needs of rural communities. In: Wallace, I. (Ed), *Rural Knowledge Systems for the 21st Century* AERDD, ADAS, SAC Proceedings 50-67.

Roling, N. and Engel, P. 1990. Knowledge management and information technology *Knowledge in Society* 3 (3), 1-12.

Roling, N. and Engel, P. 1991. The development of the concept of agricultural knowledge and information systems. In: Rivera, W. and Gustafson, M. (Eds), *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change.* Elsevier, Amsterdam, 125-137.

Roling, N.G. and Jiggins, J.L.S. 1994. Policy paradigm for sustainable farming. European *Journal of Agricultural Education and Extension* 1 (1-3), 23-43.

Roling, N.G. and Wagemaker, M.A.E. 2000 (Eds), *Facilitating Sustainable Agriculture* Cambridge, Cambridge University Press.

Rolls, M. 1998. The changing approach of the extension practitioner. In: Wallace, I. (Ed), *Rural Knowledge Systems for the 21st Century* AERDD, ADAS, SAC Proceedings 77-108.

Romig, D.E. et al. 1995. How farmers assess soil health and soil quality. *Journal of Soil and Water Conservation* 50, 229-236.

Rothamsted Research. 2004. *SUNDIAL-FRS.* http://www.rothamsted.bbsrc.ac.uk/aen/sundial/intro.htm; June 2003.

Russell, D.B. and Ison, R.L. 2000. The research-development relationship in rural communities: an opportunity for conceptual science. In: Ison, R.L and Russell, D.B. *Agricultural Extensions and Rural Development. Breaking the Traditions.* Cambridge, Cambridge University Press, 11-31.

Ruttan, V.W. 1996. What happened to technology adoption – diffusion research. *Sociologia Ruralis* 36 (1), 51-73.

Sarantakos, S. 1998. *Social Research.* London, MacMillan Press.

Scoones, I. and Thompson, J. (Eds), 1994. *Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice.* London, Intermediate Technology.

Schutz, A. 1962. *The Problem of Social Reality.* The Hague, Martinus Nijhoff.

Scottish Natural Heritage. 1997. *Soils and the Natural Heritage.* Information and Advisory Note.

Seppänen, L. and Helenius, J. 2004. Do inspection practices in organic agriculture serve organic values? A case study from Finland. *Agriculture and Human Values* 21 (1), 1-13.

Seymour, S., Turner, R., and Gerber, J. 1998a. *Farmers, their Attitudes and Practices: an Interpretation of Results from an ESRC-funded Project on Precision Farming in the Context of Nitrate Vulnerable Zone Enforcement.*

Seymour, S., Turner, R., Gerber, J. and Kinsman, P. 1998b. *Research into Cost Effective Methods of Influencing Attitudes within the Agriculture Community in the Upper Hampshire Avon Catchment.* A report commissioned by the Environment Agency.

Shackley, S. and Wynne, B. 1995. Integrating knowledges for climate change. Pyramids, nets and uncertainties. *Global Environmental Change* 5 (2), 113-126.

Shaxson, T.F. 1997. Soil Erosion and Land Husbandry. *Land Husbandry* 2 (1), 1-14.

Sheath, G.W. and Webby, R.W. 2000. The results and success factors of a farm monitoring and study group approach to collective learning. In: Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J. and Roling, N. (Eds), *Knowing and learning for change in agriculture. Case studies from industrialised countries*. Paris, INRA Editions, 111-120.

Shepherd, M.A. et al. 2000. Soil fertility in organic farming systems –are there fundamental differences between organic and conventional farmers? In: Farming Systems for the new Millennium, Association of Applied Biologists *Aspects of Applied Biology* 62. December 2000, 113-118.

Shotter, J. 1993. *Conversational Realities: Constructing Life through Language.* London, Sage Publications.

Silcock, P., Swales, V., Smith, G. and Sealy, K. 2004. Impacts of CAP Reform Agreement on Diffuse Water Pollution from Agriculture. Report for DEFRA by GFA-RACE Partners Limited in association with IEEP

Sillitoe, P. 1998. Knowing the land: soil and land resource evaluation and indigenous knowledge. *Soil Use Management* 14, 188-193.

Skinner, R.J. and Chambers, B.J. 1996. A survey to assess the extent of soil water erosion in lowland England and Wales. *Soil Use and Management* 12, 214-220.

Skinner, J.A et. al. 1997. An overview of the environmental impact of agriculture in the UK. *Journal of Environmental Management* 50, 11-128.

Smith, K.A. and Chambers, B. J. 1993. Using the N content of organic manures on farms – problems and practical solutions. *Soil Use and Management* 9 (3), 105-112.

Smith, K.A., Brewer, A. J., Dauven, A. and Wilson, D.W. 2000. A survey of the production and use of animal manures in England and Wales. I. Pig manure. *Soil Use and Management* 16 (2), 124-132.

Smith, K.A, Brewer, A.J., Crabb, J. and Dauven, A. 2001. A survey of the production and use of animal manures in England and Wales II. Poultry manure. *Soil Use and Management* 17 (1), 48-56.

Smith, J. et. al. 1997. Constructing a nitrogen fertiliser recommendation system: What do farmers want? *Soil Use and Management* 13, 225-228.

Sobels, J., Curtis, A and Lockie, S. 1999. The role of Landcare group networks in rural Australia: exploring the contribution of social capital. *Journal of Rural Studies* 17, 265-276.

Soil Management Initiative (SMI). 2002. *A Guide to Managing Crop Establishment.*

Soil Management Initiative (SMI). 2004. www.smi.org.uk; January 2004.

Soil Science Advisory Committee (SSAC). 1998. *Second Critical Analysis of UK Soils Research 1997 –2002*
www.nerc.ac.uk/funding/tfwsci/ssac_priority.shtml#r&d; August 2001.

Soil Survey and Land Resource Centre (SSLRC). 1993. *Risk of Soil Erosion in England and Wales (map).* Silsoe, SSLRC.

Steinbeck, J. 1976. *The Grapes of Wrath.* New York, Penguin Books.

Stocking, M. and Murnaghan, N. 2001. *Handbook for Field Assessment of Land Degradation.* London, Earthscan Publication Limited.

Talawar, S. and Rhoades, E.R. 1998. Scientific and local classification and management of soils. *Agriculture and Human Values* 15 (3), 3-14.

Tebrugge, F. and Bohrnsen, A. 2001. Farmers and experts opinion on no-tillage in West Europe and Nebraska. In: Garcia-Torres L, Benites, J. and Martinez-Vilela, A. (Eds), *Conservation Agriculture. A World-wide Challenge* Volume 1, 61-71.

Thompson, T.R.E. 1992. An approach to the setting of environmental quality objectives for soil and land. *Biologist* 39, 13-4.

Thompson, T.R.E. and Beard, G.R. 1989. *An Assessment of the Principles of the Soil Protection in the UK. Volume III Risk and suitability mapping in selected areas.* ITE, NERC.

Thompson, T.R.E. and Bullock, P. 1994. The justification for a soil conservation policy for the UK. In: O'Halloran, et al. (Eds), *Geological and Landscape Conservation.* London, Geological Society, 53-55.

Thompson, T.R.E and Peccol, E.C. 1995. *Sustaining Land Resources. The Role of Soil Information in Planning the Sustainable Use of Land Resources.* Soil Survey and Land Research Centre, Cranfield University, Silsoe, UK.

Tsouvalis, J., Seymour, S., Watkins, C., Holloway, L., and Steven, M. 2000a. *Farmers and Precision Farming. A Study of Attitudes and Practices in*

Lincolnshire and Suffolk. Working Paper 34, University of Nottingham, Department of Geography.

Tsouvalis, J., Seymour, S. and Watkins, C. 2000b Exploring knowledge-cultures: precision farming, yield mapping and the expert-farmer interface. *Environment and Planning A* 32, 908-924.

Turner, V. W. 1974. *Dramas, fields and metaphors.* Ithaca and London, Cornell University Press.

UNEP (United Nations Environment Programme). 1982. *World Soils Policy.*

Usher, M.B. 1996. The soil ecosystem and sustainability In: Taylor, A.G., Gordon, J.E. and Usher, M.B . 1996 (Eds), *Soils, Sustainability and the Natural Heritage.* HMSO, Edinburgh, 22-43.

van Beek, P.H.G. 1997. Beyond technology transfer? *European Journal of Agricultural Extension and Education* 4, 183-192.

van Crowder, L. and Andersen, J. 1997. Linking research, extension and education: why is the problem so persistent and pervasive? *European Journal of Agricultural Education and Extension* 3 (4), 241-249.

van den Ban, A.W. and Hawkins, H.S. (Eds), 1996. *Agricultural Extension.* 2nd edition. Oxford, Blackwell Science Inc.

van der Born, G.J., de Haan, B. J., Pearce, D.W. and Howarth, A. 2000. *Technical Report on Soil Degradation.* RIVM Report 481505018.

van der Ploeg, J.D. 1989. Knowledge systems, metaphor and interface: the case of potatoes in the Peruvian highlands. In: Long, N. (Ed), Encounters at the Interface: a Perspective on Social Discontinuities in Rural Development. *Wageningen Studies in Sociology* 27, Wageningen, The Agricultural University, Pudoc.

van Lynden, G.W. 1995. European Soil Resources. Current status of soil degradation, cause, impacts and need for action. *Nature and Environment* 71. Strasbourg, France, Council of Europe Press.

van Lynden, G.W. 2000. *Soil degradation in Central and Eastern Europe: The Assessment of the Status of Human-induced Soil Degradation.* FAO-ISRI.

van Rompaey, A. J. J., Govers, G. van Heckle, E. and Jacobs, K. 2001. The impacts of land use policy on soil erosion risk: a case study in central Belgium. *Agriculture, Ecosystems and Environment* 83, 83-94.

Vanclay, F. 1992. The social context of farmers' adoption of environmentally sound farming practices. In: Lawrence, G., Vanclay, F. and Furse, B. (Eds), *Agriculture, Environment and Society*. Melbourne, Macmillan.

Vanclay, F. and Lawrence, G. 1994. Farmer rationality and the adoption of environmentally sound practices; a critique of the assumptions of traditional agricultural extension. *Journal of Agricultural Education and Extension* 1 (1), http://library.wur.nl/ejae/v1n1t.html; June 2004.

Vanclay, F. and Lawrence, G. 1995. *The Environmental Imperative: Eco-social Concerns for Australian Agriculture*. Rockingham, Central Queensland University Press.

Waldenstrom, C. 2002. *Constructing the World in Dialogue*. PhD thesis, Stockholm University.

Walter, G., Wander, M. and Bollero, G. 1997. A farmer centered approach to developing information for soil resource management: The Illinois Soil Quality Initiative. *America Journal of Alternative Agriculture* 12 (2), 64-72.

Ward, N. 1993. The agricultural treadmill and the rural environment in the post-productivist era. *Sociologia Ruralis* 34, 71-83.

Ward, N. 1995. Technological change and the regulation of pollution from agricultural pesticides. *Geoforum* 26 (1), 19-33.

Ward, N., Marsden, T. K. and Munton, R.J.C. 1990. Farm landscape change: trends in upland and lowland England. *Land Use Policy*, 7, 291-302.

Ward, N. and Munton, R. 1992. Conceptualising agriculture –environment relations. Combining political economy and social cultural approaches to pesticide pollution. *Sociolgia Ruralis* 32 (1), 127- 145.

Ward, N., Clark, J., Lowe, P. and Seymour, S. 1993. *Water Pollution from Agricultural Pesticides*. Centre for Rural Economy Research Report No 3, Department of Agricultural Economics and Food Marketing, University of Newcastle upon Tyne.

Ward, N. and Lowe, P. 1994. Shifting values in agriculture: the family farm and pollution regulation. *Journal of Rural Studies* 10 (2), 173-285.

Ward, N., Lowe, P. and Seymour, S. 1995. Rural restructuring and the regulation of farm pollution. *Environment and Planning A* 27, 1193-1211.

Warriner, G.K. and Moul, T.M. 1992. Kinship and personal communication network influences on the adoption of agricultural conservation technology. *Journal of Rural Studies* 8 (3), 279-291.

Whitby, M. and Adger, W.N. 1996. Natural and reproducible capital and the sustainability of land use in the UK. *Journal of Agricultural Economics* 47, 50-65.

Whittemore, C.T. 1998. Structure and processes required for research, higher education and technology transfer in the agricultural science: a policy appraisal. *Agricultural Economics* 19 (3), 269-282.

Wilson, G. 2001. From productivism to post productivism and back again? Exploring the (un)changed natural and mental landscapes of European agriculture. *Transactions of the Institute of British Geographers* 26 (1), 77-102.

Wilson, T. 1987. Trends and issues in information science- a general survey. In: Barret, B.O. and Brahand, P. (Eds), *Media Knowledge and Power.* London, Open University Press, 407-422.

Wilson, G., Peterson, J.E. and Holl, A. 1999. EU members state responses to Agri-environmental regulation 2078/92/EEC: towards a conceptual framework? *Geoforum* 30, 185-202.

Wilson G.A. and Hart, K. 2001. Farmer participation in agri-environment schemes: towards conservation-oriented thinking? *Sociologia Ruralis* 41 (2), 254-274.

Winklerprins, A.M.G.A. 1999. Local soil knowledge: a tool for sustainable land management. *Society and Natural Resources* 12, 151-161.

Winter, M. 1995. *Networks of Knowledge: A Review of Environmental Advice, Training, Education and Research for the Agricultural Community in the UK.* Report to WWF.

Winter, M. 1996. Landwise or Land Foolish? Free conservation advice for farmers in the wider English countryside. *Landscape Research* 21 (3), 243-263.

Winter, M. 1997. New policies and new skills: agricultural change and technology transfer. *Sociologia Ruralis* 37 (3), 363-381.

Winter, M. 2000. Strong policy or weak policy? The environmental impact of the 1992 reforms to the CAP arable regime in Great Britain. *Journal of Rural Studies* 16 (1), 47-60.

Winter, M., Gasson, R., Curry, N., Selman, P. and Short, C. 1996. *Socio-Economic Evaluation of Free Conservation Advice Provided to Farmers in England by ADAS and FWAG.* Cheltenham, Countryside & Community Press.

Winter, M. and Gaskell, P. 1998. The *Agenda 2000* debate and CAP reform in Great Britain. Is the environment being sidelined? *Land Use Policy* 15 (3), 217-231.

Winter, M. and Murry, G. (Eds). 1998. *Networking Scientists and Farmers. The Technology Interaction Challenge for Sustainable Agriculture.* Report to WWF-UK.

Winter, M., Mills, J., Lobley, M. and Winter, H. 2001. *Knowledge for Sustainable Agriculture.* Report to WWF.

World Resources Institute. 2000. *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life.* Oxford, Elsevier.

Wynne, B. 1991. Knowledges in context. *Science, Technology and Human Values* 16, (1), 111-121.

Wynne, B. 1994. Scientific knowledge and the global environment. In: Redclift, M. and Benton, T. (Eds), *Social Theory and the Global Environment.* London, Routledge, 169-189.

Wynne, B. 1996. May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. In: Lash, S., Szerszynski, B. and Wynne, B. (Eds). *Risk, Environment and Modernity: Towards a New Ecology.* London, Sage Publications, 44-83.

Yin, R.K. 1989. *Case Study Research: Design and Methods.* London, Sage Publications.

Zola, E. 1887. *La Terre.* Paris, Editions Flammarion.

Appendix 1

AGRICULTURAL SOIL USE AND ADVICE IN UK: FURTHER FACTS

A1.1 Legislation which impacts agricultural soil

Table A1.1 Legislation which has some impact on agricultural soil use in UK.

1991 EU Nitrates from Agricultural Sources Directive 91/676/EEC implemented under Water Resources Act 1991	Protects water from nitrate pollution. Control measures rose from covering 8% to 55% of England designated as NVZs. Compulsory compliance by farmers. Designation of NSA schemes (now finished). Polluters can be prosecuted under the Act.
EU Directive 96/61/EU IPPC Integrated Pollution Prevention and Control 1999	Seeks to reduce emissions to air, soil and water from industry including larger pig and poultry units.
EU Water Framework Directive 2003	Aims to control diffuse pollution and will cover P based pollutants. UK signatory in 2003 with final deadline for compliance for all sections in 2013.
EU Framework Directive on Waste 91/156/EEC and 91/692/EEC implemented by Waste Management Licensing regulations 1994 (under the Environment Protection Act 1990	Regulates waste disposal and pollution of soil.
Directive 86/278/EEC Sewage Sludge Use in Agriculture implemented in the UK by Sludge Regulations 1989	Governs the storage and levels of sludge treatment for crop application to limit heavy metal build up.
EU directive 85/337/EEC Environmental Impact Assessment Regulations 2001	Prevents ploughing up of certain habitats for cultivation.
Environmental Protection Act 1990	Protects air, land and water from contamination from harmful substances.
Highways Act 1980	Can be used to prosecute farmers who cause a nuisance with sediments on the roads.
Countryside and Wildlife Act 1981	Habitats conservation. A range of soil ecosystems are indirectly protected within designated sites.
Town and Country Planning Act 1986 Town and Country Planning Regulations 1990	Structure plans and local plans must have regard to PPG 7 - safeguarding the best and most versatile agricultural land (ALC grades 1-3a).
UK Biodiversity Action Plans 1994 England Biodiversity Strategy 2002	Strategic ways to enhance biodiversity, should include soil biodiversity

A1.2 MAFF Indicators for Sustainable Agriculture

Pilot Indicators for Sustainable Agriculture proposed by MAFF (2000a) which are relevant to soil include:

- nitrate and phosphorus losses from agriculture;
- phosphorus levels in agricultural topsoils;
- organic matter content of agricultural topsoils;
- accumulation of metals in agricultural topsoils;
- area of agricultural land;
- change in land use from agriculture to hard development; and
- area of agricultural land under commitment to environmental conservation

A1.3 Fertiliser Advisers Certification and Training Scheme (FACTS) National Training Syllabus

Training and certification involves a 5 week course followed by an examination. The curriculum includes:

- soil in relation to plant nutrition;
- nature and properties of fertilisers;
- organic fertilisers;
- crop nutrients and the basis for calculating the amount of fertilisers required;
- use of fertilisers on the main crop groups in UK;
- transport, storage, handling and application of fertilisers; and
- Code of Good Agricultural Practice and legal and other requirements to protect the environment

Appendix 2

ADVICE PROVIDERS IN ENGLAND

Advisers engaged in arable advice and in public good advice (environmental protection and conservation) or what might be called extension, are distinguished. Further distinction is made between those providing on-farm one to one advice and those providing one to group advice, that is engaging with larger audiences on an infrequent basis and relying more on mass communication mechanisms. Inevitably overlaps occur as some advisers provide both arable and public good advice, sometimes combining group and individual methods. Figure A2.1 represents the main advisory sectors involved, based on this categorisation.

Tables have been compiled from estimates of resources for the UK using the following sources: Winter et al. (2001), responses obtained as part of the AgriComms review (Dampney et al. 2001), and backed up with other sources such as Archer (2001); ECOTEC (2000); Marshall (2002). The data are indicative and should not be regarded as fully complete. These different sources prevented common units for the extent of advice provided from being used.

A2.1 Arable advice providers

A2.1.1 One to one advice through agronomists

The range of advice provided by agronomists is great, running from those representatives selling chemicals and solely providing crop protection advice to those providing whole farm agronomy which comprises all aspects of crop and soil management, such as soil analysis, cultivations, nutrition, spraying rotation and machinery choice. The number of agronomists working in England is significant. The total number of BASIS[65] registered agronomists and consultants in UK is 2500, although the 1600 FACTs registered agronomists and consultants is more indicative

[65] An Independent Registration Scheme for the Pesticide Industry.

of the agronomists who will be involved in farm decisions affecting crop-soil nutrition as opposed to just crop protection.

Independent agronomists

Independent agronomists (also known as independent crop consultants) are contracted by the farmers to provide agronomic advice on a fee per acre basis. One adviser will typically look after 15-25 farmers in one area and may hold group meetings of these farmers from time to time. They often join up into agronomy consultancy groups or teams, to increase their expertise, client base and professional support. Independent agronomists usually are self employed and are generally regarded as impartial although some have links to manufacturers. A number of ADAS advisers became self employed following privatisation. An estimate of numbers can be derived from the independent agronomists' professional body the Association of Independent Crop Consultants (AICC) which has 180 members, although the number of non member independent agronomist is unknown. Recent figures show use of advisers or consultants by 30-40% of arable farmers surveyed in some Eastern England counties (Seymour et al. 1998a); 51% of farmers surveyed in NVZ catchment areas (Dauven et al. 1998), and 65% and 30% of surveyed sugar beet growers for private and state advisers respectively (Dauven and Crabb 1999).

Agricultural consultants

Agricultural consultants also provide independent advice but offer a wider range of skills than agronomists in all agricultural sectors, for example, they provide specialist advice and research in environment, business, waste disposal, soil analysis, irrigation, economic, cultivation, livestock, pollution and agronomy. Some will be self employed, and some employed by large organisations like Fieldfare and ADAS. Their clients will be individual farmers as well as larger organisations. The largest is ADAS Consulting Limited (ADAS) who employ 200 farm consultants providing a very wide range of fee paid consultancy in both the grower and corporate sectors (as well as work on behalf of MAFF). Independent consultants are represented professionally by the BIAC which has approximately 300 numbers, although this will include consultants from many agricultural disciplines; independent soil consultants are represented by the Institute of Professional Soil Scientists.

Distributor agronomists

Manufacturers supply agrochemicals and seed to farmers through distributors (also known as suppliers). These distributors employ agronomists who visit farms to provide different levels of advice as part of an agrochemical sales package. This can range from agrochemical sales for crop protection to whole farm agronomic advice. The larger more established distributors like Masstock, UPA and Agrovista who claim to offer excellence in agronomic services have a large infrastructure and have a strong in-house research and training capacity for their agronomists. Farm management companies like Velcourt and CWS also provide agronomic sales and advice to farmers, the former have 19, 000 ha of advisory service agreements.

In terms of numbers in England there are perhaps 10 large distributors such as Agrovista, UAP, Dalgetty, Masstock and Banks Cargill each employing up to 100 agronomists. This estimate is in line with Marshall's (2002) figure of 2000 distributor agronomists in the UK as a whole, with proportionately more of these in England. Recent merging of firms has reduced the number of firms and suggests an industry under pressure.

There is a somewhat blurred distinction between agronomists and commercial representatives, who restrict their activities to selling agrochemicals but may offer limited advice as well. Fearne (1991) suggests that the most frequently used information sources by farmers are merchants and commercial representatives. Although estimates in 1983 suggested that the larger companies employ around 20, 000 commercial representatives, declining fortunes of the farming industry have forced a big reduction in the number visiting farms and their contact is now replaced by telephone calls (Dexter 1983; Dampney et al. 2001). Whilst valued by some farmers, the reduction of visiting representatives and replacement by mailshots and telephone calls has been welcomed by most farmers (ADAS 1998).

Other advisers who interact with farmers on a one to one basis are Farm Business Advisers who support farmers in their business decisions and land agents who provide advice on estate and farm management. Although these will have an impact on financial decisions fundamental to farm management, they will not advise directly on arable husbandry.

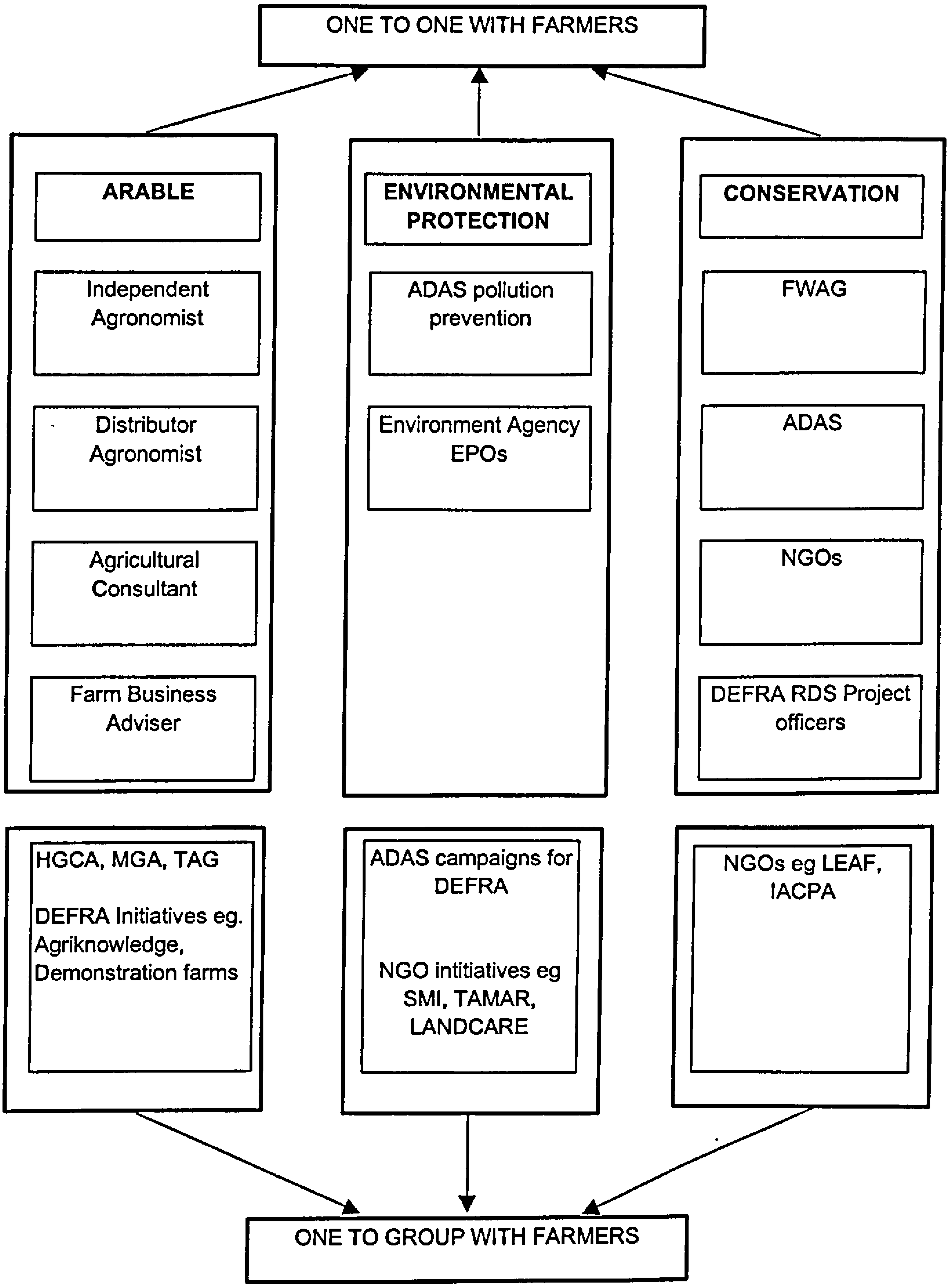


Figure A2.1 Agricultural advisers and their main advisory sectors.

Table A2.1 Estimates of numbers of agronomists and consultants in the arable sector.

Type of advice	Numbers
Distributor agronomists: eg. Banks Cargill, Dalgetty, Masstock, Agrovista, UPA Farm management agronomists, e.g. Velcourts	2000+ in UK (Marshall 2002)
Independent agronomists	AICC 180 members
Total BASIS registered agronomists/ consultants	2500 members
Total FACTS registered agronomists/ consultants in UK	1600 members receiving FACTS technical updates
ADAS consultants in UK	200 consultants
Independent consultants in UK	BIAC 300 consultants
Farm Business Advisers funded by DTI to improve business practice of farmers	Started Oct 2000 for 3.5 years, 15,000 farmer visits targeted

A2.1.2 One to group arable advice

Farmer funded organisations such as The Arable Group (TAG), formerly Morley Research Centre and the Arable Research Centre, the Maize Growers Association (MGA), and levy boards such as Home Grown Cereals Authority (HGCA) provide arable advice through newsletters, web sites, topic sheets, training and open days although personal interaction of agronomists with farmers is limited. The increase in knowledge transfer initiatives such as Agriknowledge (a DEFRA initiative to provide farmers with technical assistance) have an element of adviser-farmer interaction through workshops, roadshows and meetings and are becoming more significant. Organisations like the NFU and CLA provide branch meetings and literature and a local representative who may be approached for advice although this is rarely of a technical nature. Table A2.2 lists some of these organisations.

Table A2.2 Organisations and their activities involved in one to group arable advice provision.

Organisation	Extent and type of advice provision
HGCA and their contractors	Roadshows, breakfast meetings, demos workshops for consultants, topic sheets and website, research agronomist will interact with farmers at events and through trials.
TAG. A farmer funded research organisation formed from the merger of ARC and Morley Research Centre	ARC has 17 centres throughout England and MRI is based in Norfolk. They provide newsletters, web sites, open days, demo sites. Research agronomists interact with farmers at open days and on-farm trials.
Agriknowledge initiative 2000- 2003 Helping farmers back to profit. Led by ADAS. DEFRA funded includes the HGCA, IACR Rothamstead, Morley Research Centre and the University of Nottingham	Free business and technical advice through workshops and roadshows

A2.2 Public good advisers

These advisers promote environmental protection, best management practice and conservation; they work for publicly funded organisations, collaborative projects and NGOs using a combination of mechanisms for engaging farmers but mostly rely on mass media approaches and campaigns and have limited resources for farm visits. The focus of different initiatives will differ, while some, like ADAS advisers, act as extentionists for government policy, others, like SMI, promote projects that enhance production and profit with associated environmental benefits.

A2.2.1 One to one environmental protection and soil best management practice advice

ADAS advisers provide free farm visits for DEFRA funded anti-pollution schemes. Environment Agency Environmental Protection Officers (EPOs) also visit farms to regulate environmental protection. Details are listed in Table A2.3.

Table A2.3 Free ADAS and Environment Agency adviser visits.

Scheme	Details	Extent of advice
Supported implementation of the NVZ scheme	16 consultants working in targeted catchments	1100 visits in 98-2000 period
ADAS provide free pollution advice -under contract to MAFF	Ran from 1987 to 1996	3000 visits per year 1987-1996
ADAS FWMP offers free consultancy advice in preparation of FWMP	From 1994 to 2000 in targeted catchments, is a key part of the Water Code	500 farm visits per year
The EA Environmental Protection Officer (EPOs)	400-500 Environment Protection Officers (EPOs) who regulate farm waste activities.	

A2.2.2 One to group environmental protection and soil best management practice advice

ADAS advisers

ADAS are contracted to deliver DEFRA environmental protection messages which involve promotion of the Codes of GAP for soil, air and water and best management practice derived from the Codes and from research projects such as nutrient and manure management. These advisers will use a combination of mass media approaches such as literature, campaigns, roadshows, demonstrations and farm visits, all free, to engage farmers and consultants. Details are provided in Table A2.4.

Advisers linked with initiatives

Other advisers work within non profit making collaborative projects and knowledge transfer initiatives with a specific dissemination objective such as IFS and are drawn from different organisations involved in public good research/advice including the Environment Agency, ADAS, Game Conservancy Trust and the Allerton Trust. Often projects are collaborative or will have evolved from a research project e.g. UK Soil Management Initiative from LIFE-IFS. Some projects emphasise the practical and economic aspects of farming such as SMI, TAMAR 2000 and EnSus, some the environmental benefits of IFS such as LEAF and the BEAM project in the Marches. Adviser-farmer contact is at workshops and demonstrations. The target audiences include advisers as well as farmers. Table A2.5 sets out the key initiatives.

Table A2.4 ADAS involvement in DEFRA statutory work.

Project	Details	Method and extent of delivery
Controlling Erosion: Risk Assessment	Since 1998 - developed to advise farmers and advisers about erosion risk on their farm and practical farming techniques for avoiding erosion.	Manuel, leaflets and field guide. Campaign in 6 vulnerable areas. Seminars for consultants and organisations like EA, EN and NT. Workshops for farmers in vulnerable areas.
Managing Livestock Manures Series of three booklets	Produced in 1999 ADAS jointly with IGER and SRI.	10, 000 of each distributed
MANNER PC model	Launched first in 1997. Decision PC tool for farmers to enable them to determine how much manure to add and integrate with artificial fertiliser.	Followed by publicity campaign. 4000 copies distributed to date
'Making the most of manure' demonstration based project	1997-present	4 demo farms, attended by 147 99/00; 10 seminars over 2 winters attended by 200; 10 workshops for consultants, and presentations at key events, press articles
Revised RB209 Fertiliser Recommendations for Arable and Horticultural Crops	Launched 2000	Guide available for all farmers and advisers. Cost £15. 300 copies sold to date. 7 roadshows for target audience during winter 2001, 100 at each roadshow
CoGAP for Soil	Revised 1998	Sent to all farmers. Farmers are required to keep a copy for FASs

A2.2.3 One to one conservation, habitat and landscape advice

Rural Development Scheme advisers

POs and APOs working within DEFRA's RDS provide advisory visits in connection with ESA, CCS etc. which covers grant applications, conservation advice as well as technical aspects of responsible arable husbandry. Contact will be through a one-off farm visit and group meetings. Estimates of the advice element within the project management are 30% of the POs time (Juntti and Potter 2002). Advisers working for the OAS (administered by EFRC) offer specialist advisory visits to farmers converting to organic agriculture with a free one and a half day visit, this service is part of the OCIS scheme. Winter et al. (2001) reported 50 full and part time advisers, although this has subsequently declined to 35 and is now building up again. These advisers are recruited from the independent sector. Table A2.6 sets out the numbers of POs and organic farming advisers and the number of farm visits they make.

Table A2.5 Advisers' involvement in initiatives related to soil best management practice.

Initiative	Collaborators/funders	Method and extent
SMI	Set up in 1999 and funded by the EU LIFE fund, European Conservation Agriculture Federation and some DEFRA support	Demonstrations, farmer and adviser workshops and literature.
Reducing winter run off from maize fields	MGA and Environment Agency	10 MGA demo plots open to all
Landcare Upper Hants Avon	Environment Agency initiative with MGA, EN, Wessex Water, BIAC etc.	Demo farms, meetings, literature
LEAF- develops and promotes integrated farming	1500 farm members, 19 corporate, 33 colleges, 365 audits returned	40 demo farms
BEAM project in the Marches	5b Objective project ADAS	Demonstration farm, workshops and meetings
EnSus farming club Devon and Cornwall	5b Objective project ADAS	
TAMAR 2000 SUPPORT, SW	5b Objective project ADAS	367 farm visits, 370 members

Table A2.6 Number of advisers and visits within the RDS.

Organisation	Number of advisers	No. of visits
DEFRA RDS	119 APOs and POs in FRCA 2001	98/99 14,000+ free conservation advisory visits in connection with ESA and CCS and 1210 advisory visits to farmers in Habitat scheme and NSA farmers
Organic Advisory Service provided as part of OCIS	40-50 plus FT and PT advisers from OAS/EFRC	2682 visits in 99-00

Conservation advisers

Conservation advice is dominated by FWAG. The number of visits increased from 3500 in 1993/94 to 4723 in 1998/99, and the number of advisers increased from 35 to 54 in England between 1994 and 1999 (Winter et al. 2001). The initial visits are free after which farmers are encouraged to pay. Advice is unevenly distributed with some counties having more advisers than others (Winter 1995; Winter et al. 2001). Many farmer are increasingly seeking FWAG advice in preference to ADAS who also deliver free conservation advice to farmers (Winter et al. 1996). NGOs such as the National Trust, RSPB, GCT, Allerton Trust and local Wildlife Trusts provide advisers on a much smaller scale. The National Trust recently started employing Farm and Countryside Officers who fulfil a similar role to FWAG advisers on their tenant farms. Agencies such as the Environment Agency, English Nature and local authorities, national parks also play a role while other organisations such as the Countryside Agency within their Land Management Initiatives provide some limited advice.

In terms of numbers of farmers using conservation advice, surveys have suggested quite extensive use. An OMNIFARM farmer survey (CEAS Consultants 1991) found that 28% of respondents had taken conservation advice during the previous 12 months and a Pieda survey (Pieda 1992) found 37% farmers in sample from Devon, N. Yorks and Suffolk had received some advice on conservation and environmental management. However, a significant amount of this advice had in fact been derived from mainstream commercial sources or linked to them (Winter et al. 1996).

Table A2.7 Number of advisers and visits within conservation organisations.

Organisation	**Number of advisers**	**No. of visits**
ADAS conservation advice	45 (2000)	1880 free visits in 98/99
FWAG	54 in England (1999)	4723 visits during 98/99
National Trust	12 Farm and Countryside Officers	
Environment Agency	50 Conservation Protection Officers (COP)	

Appendix 3

CASE STUDY ADDITIONAL DETAILS

A3.1 UK Soil Management Initiative

A3.1.1 SMI Activities

- Breakfast Roadshows (sponsored by Syngenta).
- Day Workshops for farmers, advisers and others in the industry which involve a morning technical seminar and presentations followed by field visit to farm demonstration plots (see Appendix for programme of day).
- Regular Press articles (member links with Crops Magazine).
- A web site with FAQ and other sources of information www.smi.org.uk.
- Lo-Till question Line on the Farmers Weekly Interactive website run by SMI members answering farmers' specific queries.
- Appearance at a range of arable events.
- Links with Crop2Soil, an HGCA initiative promoting 'Soil management for profitable crop production' with workshops, website and press coverage in 2003.
- Links with farmer Lo-Till Club.

A3.1.2 SMI Membership details

Minimum basic subscription levels based on company turnover

- less than £10 million: £350 p.a. min
- between £10 and £25 million: £500 p.a. min
- between £25 and £50 million: £1,000 p.a. min
- over £50 million: £1,500 p.a. min

Basic Membership benefits:

- Annual members conference attached to AGM
- Free quarterly newsletter
- Free SMI Guidebook to Conservation Agriculture

- Free entry to SMI Events
- Inclusion on SMI Mailing List

Higher Level Membership benefits:

- Event sponsorship opportunities
- Publication sponsorship opportunities
- More direct access to farmers
- Subsidised training opportunities
- Priority consultancy

Benefits at Board / Steering Committee level Influence SMI policy and activities (e.g. development of assurance schemes):

- Interactive expertise opportunities
- Tap into the resources of SMI links through ECAF
- Help represent SMI on the UK, EU and world stages

A3.1.3 SMI Publications

- SMI. 2002. *A Guide to Managing Crop Establishment* (DEFRA funded). The booklet and accompanying video contains 12 case studies on farms that have already, or are in the process of changing, from ploughing systems to systems of non inversion tillage. Free booklet.
- SMI. 2002. *Improved Soil Management for Agronomic and Environmental Gain.*
- Hamilton, I. 2002. *Review of Recent Research into Control of Black Grass with a Total Approach Including Cultivation Timing and Drilling Date and Stale Seedbeds.* Syngenta as presented at the SMI members day 3/12/02.
- SMI. 2002. *SMI Cost Calculator* (excel 5 file 1.4mb about 1 minute to download) the SMI cost calculator is an interactive excel file for estimating on-farm cultivation costs).
- SMI. 2002. *Changing Cultivation Practice for Environmental Gain.* SCI conference 2002.
- SMI. 2002. *The Effects of Non-inversion Tillage on Earthworms and Invertebrate Populations as Potential Food Sources for Farmland Birds.* A literature review.

- SMI. 2000. *The Impact of August Drilling and Minimal Tillage on Weeds and Weed Control – a Practitioner's View.* Aspects of Applied Biology.
- SMI. 2002. *The Environmental Benefits of Adopting Conservation Agriculture – the Evidence from European Research.*
- SMI. 2002. *Soil Management for Economic and Environmental Gain.* Leaflet.
- Markham, G. and Chapman, T. 2000. *Lo-Till: The Financial Effects of Progressive Adoption.* 14 page handout at the 2000 Royal Show (Grant Thornton).

A3.1.4 Other relevant publications

- Garcia-Torres L., Benites, J. and Martinez-Vilela, A. (Eds), 2001. *Conservation Agriculture: A World-wide Challenge* Congress Proceedings Volume I and II.
- European Conservation Agriculture Federation. no date. *Conservation Agriculture in Europe: Environmental, Economic and EU Policy Perspectives.*
- Monsanto (no date) Conservation Agriculture: *A Decision Making Guide to Reduced Tillage Systems.*
- Cranfield University. 2001. *A Guide to Better Soil Structure.* National Soil Resource Institute
- Vaderstad. no date. *The Establishment Business.*

A3.1.5 Most frequently asked questions from the SMI web site

- Why will Reduced Cultivation succeed now, when it failed in the '70's?
- Surely the cheapest method of establishment is the one you already have? Any expenditure only benefits the machine manufacturers?
- Will Reduced Cultivating send my slug control bill sky high?
- What is the long-term impact on compaction and natural drainage?
- Are there any soil types not suited to Reduced Cultivation methods?
- Should light and heavy soils be managed differently?
- How effective is Reduced Cultivation equipment at incorporating bulk organic matter products such as sewage sludge cake and paper waste?
- What are the pros and cons of different Reduced Cultivating drills? How do I improve my plough tillage?

- What's the situation of No-tillage in UK? How does one maintain soil sustainably?

A3.1.6 Article from SMI website

COMPACTION NEEDS CURING 20 July 2002 Paddy Johnson, Speaking at a Soil Management Initiative open day in Nottinghamshire.

With early crops now being harvested, farmers are being urged to do a little digging if they want to ensure they achieve optimum crop performance next season.

'Compaction caused by cultivating damp soils and harvesting crops in wet during the past two autumns is costing British farmers millions of pounds in lost yields, and desperately needs curing', says Paddy Johnson, Soil Scientist for ADAS:

Do the following seem familiar?

- Use of a crawler tractor to pull a wheeled tractor so it could continue ploughing. A tractor up to its axles being pulled out by another tractor. Both these cases were in fields that grew sugar beet in 2002 and with a wet November had already been abused by sugar beet harvest. Did they need more abuse?
- Why the desperation to sow wheat with an anticipated value of £55 a tonne? With the mauling those fields had received yields will not be 10 t/ha for certain.
- Surely set-aside would be a better option. This would allow the sowing of a cover crop of some sort in spring to help dry out the soil, start repairing the structure and possibly dry the soil sufficiently for sub-soiling post set-aside if a session of soil examination showed it necessary.
- But these are not the only fields around where there are problems apparent. Many fields have standing water where run-off has concentrated. How much of this is due to overworking the soil and producing a very fine seedbed which collapsed under raindrop impact? There is a good chance that a hole dug under the flooded patch would show dryish soil within the topsoil.
- Flooded patches don't mean the drainage system has necessarily gone wrong. But just the same apart from getting the spade out and digging holes, not just

now but in spring when problems show up in crops, why not check drain outfalls. If the outlets are blocked there is no chance of water getting away from the field. If there are blockages or the outfalls are broken – sort them. When you find the drains mark them so they are easier to find next time. Some wet patches may be due to broken drains, but others may be caused by springs – in very wet weather such as we had in November even small light patches of soil can act as mini aquifers and develop springlines.

Action: Explore wet patches find out reasons by checking drains, compaction, soil structure in spring and correct the problem for the next crop.

A3.1.7 SMI case study: Interview themes

A. Farmers

- Interest in the project and reasons for attending SMI event.
- Reaction to the project and the event –perceived benefits.
- Experiences with reduced tillage.
- Reasons for changing to reduced tillage or for keeping the plough.
- Sources of information about reduced tillage.
- Use of advisers –views on their competence.

B. SMI board members

- Project involvement, reasons for involvement.
- Interpretation of SMI key message.
- Transformation of research to advisers/farmers and the role of SMI.
- Links with and opinion of advisers.
- Links with farmers and their involvement in SMI.
- Areas of Conflict. Different agendas of people on SMI board.
- Environmental benefits effects contested.

C. Non-SMI advisers

- Opinion of SMI and reduced tillage.

- Competence and experience of advisory community.
- Helping farmers generally with soil management.
- Views of farmers experience and uptake of reduced tillage.
- Soil/ environmental benefits.

A3.2 Landcare

A3.2.1 Dissemination activities

Landcare has used a combination of demonstrations, farmer workshops and literature. This format was used rather than one to one farm visits because they are more cost effective.

- Demonstrations were initially established on the Pembroke estate with the co-operation of the farm manager after certain fields were identified as potentially erosive.
- Farm visits did continue to problem farms from the project officer in his capacity as an EPO.
- Workshops. Based on a visit to a small mixed farm which had previously been identified by the EPO as needing to improve practices. These involve a technical presentation followed by a field visit where farmers and advisers were invited to design and monitor trials. Using an independent agronomist to run these workshops and make presentations proved most effective. Two were held at 6 month intervals with the intention that the effect on soil and yield of decisions could be evaluated. Adverts for the workshops were placed in Crops magazine and attracted farmers and advisers from some distance although local farmers were poorly represented.
- Literature. In the early phase a 'toolkit' (funded by English Nature), a file of literature intended as a guide to the various codes of good practice, was produced and distributed to all farmers in the catchment. This happened despite opposition within the partnership from those who argued that it was far too big and unwieldy and that farmers did not have time, nor the inclination, to read such material.
- NFU included relevant material in their Branch Newsletter.
- NFU Branch meetings hosted discussions lead by the Environment Agency.
- Occasional presentations by an independent adviser contracted by the Environment Agency in the local pub.

- The BIAC consultant partner has been active for a number years for the Environment Agency carrying out FWMP.

A3.2.2 Research and monitoring activities and related publications

- SSLRC. 1997. *The Vulnerability of Land within the Hampshire Avon Catchment to Soil Erosion by Water.* A report for the Environment Agency which classified the majority of the upper catchment as 'moderate erosion risk' but identified locally high risks areas within this.
- Bryson. 1998. *Landcare Monitoring Strategy.* Identified need for monitoring.
- Environment Agency. 2002. *Landcare Baseline Monitoring Report.* Provides a baseline on the state of the Hampshire Avon catchment and will assist in determining whether Landcare is having an impact on reducing diffuse pollution. Results suggest the river water quality was good but limited sampling did not capture high flow events. Plus evidence of high suspended soil nutrient and pesticide levels from rainfall activated work identified hot spots which needed more investigation.
- Fieldfare Associates. 2000. *Nutrient Management Survey in the Pewsey Vale.* Report to Environment Agency.
- Clements, R. O. and Donaldson, G. 2001. *Soil Erosion Control in Maize.* Environment Agency Draft Report SP 0404.
- Environment Agency. 2002. *Soil Erosion Control in Maize.* Environment Agency R&D Technical Report P2-123/TR in combination with Maize Growers Association. The results of field experiments made using hydrologically sealed plots during three winters of 1998 to 2001 at Long Ashton near Bristol, two winters of 1999 to 2001 at North Wyke in Devon and one at Frithelstock in North Devon during 2000/01 are reported.
- Environment Agency. 2001. *Best Farming Practices: Profiting from a Good Environment.* Environment Agency R&D Publication 23.
- Seymour, S., Turner, R., Gerber, J. and Kinsman, P. 1998. *Research into Cost Effective Methods of Influencing Attitudes within the Agriculture Community in the Upper Hampshire Avon Catchment.*
- Accent Research and Marketing. 2002. *Farmer Survey of Knowledge and Attitudes Towards Diffuse Farm Pollution.*

A3.2.3 Other relevant publications

Although not specific to Landcare some research looking into farmers' attitudes towards using manures and policy mechanisms for controlling diffuse pollution has been recently undertaken and can be used to inform this study.

- Dwyer, J., Eaton, R., Farmer, A., Baldock, D., Withers, P. and Silcock, P. 2002. *Policy Mechanisms for the Control of Diffuse Agricultural Pollution, with Particular Reference to Grant Aid.* English Nature Research Reports Number 455.
- Smith, K.A., Brewer, A..J., Dauven, A. and Wilson, D.W. 2000. A survey of the production and use of animal manures in England and Wales. I. Pig manure. *Soil Use and Management* 16 (2), 124-132.
- Smith, K.A, Brewer, A.J., Crabb, J. and Dauven, A. 2001. A survey of the production and use of animal manures in England and Wales II. Poultry manure: *Soil Use and Management* 17 (1), 48-56.
- ADAS 1998. *Attitudes Towards Changing Practices in the Management of Animal Manures Outcome of Focus Groups.* Report to RMED, MAFF.

A3.2.4 Landcare case study: Interview themes

A. Landcare partners

- Landcare history, funders, partners, key individuals.
- Involvement in the project, role.
- Objectives and main messages, limitations and strengths.
- Partnership - agreement or conflict?
- Research basis to project.
- Links and views on with advisers in Landcare area.
- Views on farmers experiences with and involvement in project.
- Views on best management practices.
- Responsiveness of farmers to environmental protection messages.
- Areas of conflict - farmers receiving conflicting messages from other advisers?

B. Advisers

- Job title –specialisms.
- Project awareness and any involvement.
- Awareness of diffuse pollution.
- Sympathies with project aims/ Environment Agency in general.
- Importance of keeping up to date with research and best management practice messages.
- Advisers role in promoting best management practice for such projects – conflicts.
- Advisers interaction with the farmers and mechanisms used.
- Responsiveness of farmers to best management practice messages.
- Areas of conflict - farmers receiving conflicting messages from other advisers.

C. Farmers

- Project awareness (Recollection of literature about Landcare).
- Visited any Landcare demo sites, farmers days, shows, events.
- Agreement with the premise of the project that agriculture is responsible for polluting the rivers.
- Views on responsiveness to soil best management practice messages - necessary and practical?
- Soil management knowledge and practice.
- Views on reconciliation of economic and environmental gain ie. win-win.
- Role of the adviser - influential/ confidence in competence.
- Agronomist views and support for best management practice.
- Sources of information. Events attended, memberships of associations. Importance of keeping up to date.

A3.3 SUNDIAL-FRS

A3.3.1 Articles in farming and industry press[66]

Addiscott, T.M., Smith, J.U., 1997. Getting nitrogen right: the role of the computer and chlorophyll meter. *The Agronomist* 3/97, 7-10.

Anon. 1995. Putting an end to Nitrogen nightmares (comment). The sunny side of research. *Crops* March 8th 1995

Anon. 1995. Hard and fast Guidelines not easy to give (nitrogen leaching). *Farmers Weekly* 3rd Feb 1995 p53.

Anon. 1995. Nitrogen dynamics the key to forecasting fertiliser need. *Farming News* 24th Feb 1995 p20.

Anon. 1996. Timely tool should help cut leaching. *Farmers Weekly* 27th Dec 1996.

Anon. 1996. Computer predictions give promising results. *Farming News* 15th Nov 1996 p17.

Anon. 1996. Nitrate-cycle computer model research extended. *Agricultural Supply Industry* 1st Mar 1996 p8.

Anon. 1996. SUNDIAL model predicts soil nitrate losses. *Farming News* 8th Mar 1996 p18.

Anon. 1997. Rotation alters leaching. *Farmers Weekly* 26th Dec 1997.

Anon,. 2000. N-model here by 2001. *Farmers Weekly* Mar 17th 2000.

Blake, A. 1998. Promising model on trial. *Farmers Weekly* 1st May 1998, p66.

Dampney, P., Rahn, C.R., Smith, J.U., 1999. *Nitrogen Fertilisation of Field Crops - an Update*. London, MAFF Publications.

Glendining, M. J. 2001. Implications of the very wet autumn on fertiliser N recommendations. *ARIA Newsletter* 1. Feb 2001.

Smith, J.U., 1999. Using models of nitrogen turnover on working farms. *Agriculture Link. July 1999. p 6.*

Smith, J.U., Glendining, M.J., 1998. Modelling crop nutrition - An overview - How will it work, what benefits and when? *RASE: Cereals Conference "Using New Technology to Reduce Costs"* Feb 4th & 5th, 1998, York and Peterborough.

[66] A list provided by the researchers involved.

A3.3.2 SUNDIAL-FRS case study: Interview themes

A. Researchers

- General links between Rothamsted researchers and advisers and farmers.
- Comments on the initiative for development of original model into FRS – funding.
- Objective of FRS: Meeting needs of the farmer? Or green agenda?
- Confidence in model predictions.
- Objective of the consultation.
- Process of consultation: selection of advisers and farmers; nature of consultation.
- Response to results from the questionnaire, any surprises?
- Changes made as a result of the consultation.
- Differences in feedback from farmer and advisers.
- Compatibility of FRS recommendations and farmers activities.
- Value of personal interaction in consultation – were expectations from the advisers and farmers raised?
- Outcome: Commercial development and availability.
- Superseded by other models?
- Researchers Role - conflict in meeting requirements of MAFF to reduce leaching and meeting practical requirement of farmers.
- Current version and research activities/ Frustration in lack of progress.

B. Farmers

- Reason for interest, participation.
- Use of models and other systems generally.
- Opinion of Rothamsted /Opinion of researchers involved, attitude, motivations.
- Method of consultation.
- Objective of the FRS -reduce leaching or improve farm efficiency?
- Availability of inputs on farm/ Ease of use.
- Recommendations comparable with other methods.
- Was the need for something like this model identified by farmers/ Expectation of FRS –would it be used.

- Adviser use of model.
- Adviser role in linking farmers to Rothamsted.
- Farmer feedback made any difference.

C Advisers

- Rothamsted – AICC links in general.
- Opinion of models.
- Use of research tool to develop FRS.
- Objective of FRS/ Need for FRS identified in practical community?
- What do farmers and advisers currently use.
- Mechanism and outcome of consultation.
- Feedback accepted and changes made?
- Common requests raised.
- Links sustained with the project.
- Farmers and advisers use of FRS if available or reluctance.
- Is this involvement and interest from advisers typical.
- General advisers role in promoting best management practice messages for DEFRA.

A3.4 Letter accompanying questionnaire

Dear

Questionnaire: Provision of advice on soil management to farmers

I am carrying out research for a PhD (funded by the Economic and Social Research Council) into the transfer of information about soil management between researchers, advisers and farmers in England. As part of this research a questionnaire survey is being conducted of advisers (consultants) who provide information and advice about soil management to farmers. The questionnaire is being sent to advisers selected from a range of organisations that provide agricultural advice in England. The purpose of the questionnaire is to obtain information from advisers themselves about how they interact with the research and farming communities.

I would be very grateful if you could fill in this questionnaire, which is as simple as possible with most questions only requiring you to tick boxes. All the information you provide will be treated with complete confidence and used only in summary or statistical format; you will not be identified in any way.

When you have completed the questionnaire please return it in the pre-paid envelope by 15 August 2001.

If you have any queries please phone me on 01608 676257.

Thank you for you co-operation.

Yours sincerely,

Julie Ingram

A3.5 Adviser questionnaire

ADVISER QUESTIONNAIRE - PLEASE FILL OUT ALL 3 SECTIONS.

Definitions of terms used in the questionnaire:
Soil protection – this refers to protection in its broadest sense where long-term damage to soil is avoided
Soil degradation – this refers to any short or long-term damage to soil that impairs its functions

****

YOUR PROFESSIONAL BACKGROUND AND CURRENT EMPLOYMENT

1. Name.....................................

   Address.................................

   ....

   ....

   ....

2. Name of organisation/employer

   ....

3. *Very* briefly describe the main aspects of your job and its main objectives

   ....

   ....

4. What is your highest qualification which is relevant to your current job?

❑NCA ❑OND ❑GCSE/O level ❑A level ❑HND
❑BSc/BA ❑MSc/MA ❑PhD ❑Other (specify)

5. Length of experience as an adviser (approximate number of years)

   ....

6. What professional organisations/societies do you belong to?
(Tick all appropriate boxes)

❑AICC ❑BIAC ❑BASIS ❑BSSS ❑RASE
❑RASA ❑IPSS ❑IEEM ❑RICS ❑FMA
❑FACTS ❑Other (give details)

7. Approximately how many other advisers are there in your organisation who cover agronomy/soil related issues?

....

8. What geographical area/region does your current job cover?

....

9. What soils predominate in this area?

....

10. Have you recommended any of these management options in the last 2 years? (Tick as many boxes as appropriate)

☐Grass rotations ☐Green manures ☐Cover crops ☐Carefully timed cultivation

☐Minimum tillage ☐Bi-cropping ☐Precision farming ☐Low compaction machinery

☐Buffer strips ☐Permanent grass ☐Contour ploughing ☐Earlier autumn sowing

☐Reduced and targeted N applications ☐Reduced manure application in autumn/early winter

☐Consideration of the manure N value in N fertiliser recommendations

11. Have you undertaken any specialist training or research to help you provide advice on these management options? ☐Yes ☐No

If yes give *brief* details of what the training was for and where you received the training.

....

....

12. What do you understand by the term 'sustainable soil management'?

....

....

....

....

13. To what extent do you think soil degradation is a problem in English agriculture? (Tick one box only)

☐no problem ☐don't know ☐ problem

14. How often do you use or recommend to farmers the following DEFRA (MAFF) publications (Tick one box only for each item)

	Never	Sometimes	Always
Code of Good Agricultural Practice for the Protection of Soil	❐	❐	❐
Code of Good Agricultural Practice for the Protection of Water	❐	❐	❐
Fertiliser Recommendations RB 209	❐	❐	❐
Controlling Erosion Manual	❐	❐	❐
Managing Livestock Manures Booklets 1-3	❐	❐	❐
Guidelines for farmers in Nitrate vulnerable Zones	❐	❐	❐

15. List other Guidelines or Codes you use regularly for your job.

....

....

16. Are you aware of any of the following?
(Tick as many boxes as appropriate)

❐The National Soil Strategy ❐RCEP 1996 Report 'Sustainable Use of Soil'

17. Which of the following tools do you use when advising farmers?
(Tick as many boxes as appropriate)

❐MANNER Model ❐FERTIPLAN ❐EMA ❐LEAF Audit
❐FWAG Landwise ❐Soil Survey maps/Regional Bulletin
❐Other (specify)

18. What level of priority do you in your current job give to soil protection?
(Tick one box only)

❐low ❐neither low nor high ❐high priority

B. YOUR LINKS WITH RESEARCH

19. Does your organisation conduct research which has relevance to agricultural soil management?

❑Yes ❑No

If yes, how is this research organised?
(Tick as many boxes as appropriate)

❑Field trial ❑On farm (Researcher led) ❑On farm (Farmer led) ❑Other (specify)

20. Which of the following sources of information are most important for you to keep up to date about soil management research?
(Select the 5 most important)

❑Training courses
❑Farming press, TV, radio
❑Research Institutes
❑Personal contacts with other advisers
❑Scientific/agricultural journals
❑ADAS/DEFRA internet/ publications
❑BIAC/BASIS/AICC
❑CLA /NFU
❑Demonstration farms
❑Agrochemical companies
❑Organic Information Service
❑Soil Association/ HDRA
❑Levy bodies, eg.HGCA
❑Other (give details)
❑Newsletters
❑Conferences/Workshops/seminars
❑Personal contacts with researchers
❑Personal contacts with farmers
❑Technical bulletins/notes/R&D publications
❑Other advisers/advisory services
❑LEAF
❑Agricultural shows
❑Environment Agency
❑FACTS Technical Information Service
❑BSSS
❑FWAG/conservation groups
❑ARC, Morley Research Station

21. Do you have any direct input into agronomic/soil research or do you conduct research yourself?
❑Yes ❑No

22. Do you have the opportunity to feedback farmers reactions and ideas about agronomic/soil research to researchers? ❑Yes ❑No

If yes give a *brief* example of how this is arranged

....

23. To what extent do you see the following as limiting the effectiveness of research on soil management (Tick one box for each statement)

	not limiting	don't know	limiting
Research is of limited practical use to farmers	❑	❑	❑
Research does not have an adaptive/applied phase	❑	❑	❑
Lack of co-ordination between research disciplines involved in research	❑	❑	❑
Poor dissemination of results	❑	❑	❑
Lack of co-ordination between research bodies	❑	❑	❑
Poor contacts between the research community and advisers	❑	❑	❑
Other (give details)	❑	❑	❑

C. YOUR LINKS WITH FARMERS

24. Is any of your advice to farmers offered free of charge? ❑Yes ❑No

If yes which sort of advice (Tick all appropriate boxes)

❑Conservation ❑Business ❑Environmental protection ❑Organic ❑Other (specify)

25. Approximately how many farmers are you currently advising ....

26. For the majority of your clients who initiates the adviser contact ?

❑Farmer ❑Farmer Groups ❑You ❑Other

27. In your current job are the farmers predominantly arable, livestock or mixed? (Tick one box)

❑Arable ❑Livestock ❑Mixed ❑Horticulture

28. Which of the following describe the farmers you advice. (Tick all appropriate boxes)

❑Conventional ❑Organic (registered/ converting) ❑LEAF (registered or considering)
❑Participants in or considering agri-environment scheme
❑Recipient of or considering FWAG Landwise ❑Others (describe)

29. Which of the following methods have been most effective for you when advising farmers on soil management ?
(Select the 3 most effective)

❑Discussion groups	❑Written leaflets	❑One to one consultation
❑Videos	❑Computer-aided Decision support	❑Farm demos
❑Telephone	❑Training days	❑Other (specify)

30. Indicate the severity of any incidences of degradation which you have observed in the course of your work over the last 2 years which can be attributed to inappropriate land use or poor soil management?
(Tick as many boxes as are appropriate)

Insignificant	Minor	Severe	
❑	❑	❑	Water erosion
❑	❑	❑	Wind erosion
❑	❑	❑	Soil contamination
❑	❑	❑	Soil Compaction
❑	❑	❑	Capping
❑	❑	❑	Poor drainage
❑	❑	❑	Poor nutrition
❑	❑	❑	Other (specify)

31. Research has shown that only a small percentage of farmers use the Code of Good Agricultural Practice for the Protection of Soil. Why do you think this is?

....

....

....

32. Do any of your clients participate in farmer discussion groups/study groups or formal networks which promote environmentally responsible farming? ☐Yes ☐No
If yes, give a *brief* example

....

33. To what extent do you agree with the following statements?
(Tick one box only for each statement)

	Agree	Neither agree nor disagree	Disagree
Soil protection is the responsibility of all farmers	☐	☐	☐
Most farmers you advise are technically well informed about soil nutrition and management	☐	☐	☐
Most farmers you advise have a good knowledge and understanding of soils on their farm	☐	☐	☐
Most farmers you advise are not concerned with good agricultural practice for soil protection	☐	☐	☐

34. How important do you think are the following factors in influencing farmers to adopt management options which protect soil.
(Tick one box for each statement)

	Not important	Neither important nor unimportant	Important
Obvious and visible degradation	☐	☐	☐
Good technical advice	☐	☐	☐
Available grants	☐	☐	☐
Persuasion by adviser	☐	☐	☐
Part of compliance with agri-environment scheme	☐	☐	☐
Part of farming system eg. IFS/ organic	☐	☐	☐
Management options that fit into current farming practices	☐	☐	☐
Nuisance, e.g. erosion onto roads /waterways	☐	☐	☐
Farmer can see a long-term economic benefit	☐	☐	☐
Specific interest in soil protection	☐	☐	☐
Other (specify)	☐	☐	☐

35. Which of the following factors do you think explains farmers non-adoption of soil protection measures/sustainable soil management.
(Tick one box for each statement)

	Not important	Neither important nor unimportant	Important
Too expensive to implement	❐	❐	❐
Lack of experience/knowledge of their own soils	❐	❐	❐
Lack of knowledge and skills about new management options	❐	❐	❐
Does not fit into current farming practice easily	❐	❐	❐
Ignorance of the problem	❐	❐	❐
Lack of information/advice	❐	❐	❐
Adviser's lack of experience	❐	❐	❐
Lack of concern/stewardship ethic	❐	❐	❐
Lack of available grants	❐	❐	❐

36. Have you come across any examples of agronomic research initiated/undertaken by farmers themselves, independently or in small groups? ❐Yes ❐No

If yes give a brief example

....

37. Have you ever encountered a situation where your advice on soil management to a farmers has been contradicted by advice from another source. ❐Yes ❐No
If yes give a brief example

....

....

Please feel free to add any further comments on the points raised in the questions above on a separate sheet.

Thank you very much for taking the time to complete this questionnaire.