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The agriculture-water interface: Policy integration and the environment

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by

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The agriculture-water interface: Policy integration and the environment

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Abbreviations and Acronyms

ANOB	Area of Outstanding Natural Beauty
CLA	Country Landowners Association
DG	Director General of Water Services
DoE	Department of Environment
EA	Environment Agency
ESA	Environmentally Sensitive Area
IDB	Internal Drainage Board
LMC	Long run marginal cost pricing
MAF	Minimal Acceptable Flow
MAFF	Ministry of Agriculture, Fisheries and Food
MMC	Monopolies and Mergers Commission
NFU	National Farmers Union
NRA ¹	National Rivers Authority
NSA	Nitrate Sensitive Area
NVZ	Nitrate Vulnerable Zone
OFWAT	Office of Water Services
PMB	Potato Marketing Board
RFO	River Flow Objective
RWA	Regional Water Authorities
SMD	Soil Moisture Deficit Level
SSSI	Site of Special Scientific Interest
Wc	Water Companies
WCA	Water Companies Association
WSA	Water Services Association
Mgl/pa	Megalitres per annum
Mgl/d	Megalitres per day
Tcma	Thousand cubic meters per year
Tcmd	Thousand cubic meters per day
1 megalitre	220,000 gallons
1 megalitre	4.546 tcmd
10000 gallons	4.546 m ³
t/ha	tonnes per hectare

¹ During the period of this research the NRA merged with HMIP, to form the Environment Agency, in operation from the 1 April 1996.

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Summary of Thesis submitted for Doctor of Philosophy Degree

by

Sarah Elizabeth Williams

on

The agriculture-water interface: Policy integration and the environment

Although current environmental policies may prove successful against narrowly defined criteria of economic, social or environmental sustainability, it is by no means certain that the sustainability of inter-dependent economic and environmental systems will be assured. In fact, policy intervention may result in the displacement of environmental problems to other media, times or places. Farmers are the focus for divergent forces of state, market and social regulation and in consequence their response, or more importantly non-response, to environmental policies cannot be assessed in isolation. This thesis explores these complex issues through analysis of the agriculture-water interface, focusing on the allocation and regulation of abstraction water for use as spray irrigation by farmers in the eastern counties of England.

Adopting an interface-network methodology, the analysis traces the network of social relations which directly and indirectly influence the use and management of irrigation water and potential response to demand management policies, encompassing farmers' interaction with the NRA, food processing, manufacturing and retail firms as well as farmer representative groups. Risk and uncertainty play a central role shaping interaction not only between firms, but between firms and farmers as they attempt to reallocate the financial, production, legal and environmental risks associated with production. The analysis demonstrates how farmers' incorporation into the "quality projects" of the downstream food network critically distorts their response to demand management policies. This perpetuates a highly intensive system of agricultural production, contributing to the loss of landscape and wildlife habitat and diffuse pollution of ground and surface water sources. The analysis concludes by outlining an alternative agenda of action for the Environment Agency which focuses on promoting synergy between state and market forces of regulation. Only through addressing these issues will the integration of the environment and economy prove successful at the agriculture-water interface.

CHAPTER ONE

REGULATION AND THE AGRICULTURE-WATER INTERFACE: THE KEY DIMENSIONS OF THE PROBLEM

One of the central problems confronting both policy makers and analysts in the quest for sustainable development, is the complex and intricate inter-dependencies which underpin interaction between the environment and economy. There is a danger the current debate will simplify or dilute these complexities to such an extent that it will culminate in policies which focus solely on discrete problems in specific environmental media. Although these initiatives may prove successful within very narrowly defined terms of reference, and conform to the principles of economic, social or environmental sustainability, it is by no means certain the sustainable development of inter-dependent economic and environmental systems will be assured (Rees and Williams 1993). In fact, intervention may result in the dynamic displacement of environmental problems from one media, time or place to another, creating far more complex environmental problems for future peoples in distant places to deal with (Weale 1992; Janicke 1990). Consequently, it is vital to the success of the sustainable development project to address these intricate inter-sectoral dynamics and bring to an end the perpetual cross media transfer of environmental problems.

The analysis presented here will directly address these complex and dynamic processes through detailed scrutiny of the agriculture-water interface. This chapter will set out the key dimensions of the problem confronting policy makers at the agriculture-water interface, and will identify the central research questions. The first section of this chapter will concentrate on defining the critical features of the agriculture-water interface, and will reveal the plethora of competing and conflicting policies which directly and indirectly shape the use and management of irrigation water at the farm level. The second section will attempt to disentangle the complex processes at work, through developing a conceptualisation of regulation which encompasses the multiple layers of direct and

indirect state, market and social forces of regulation. The final section will conclude by drawing together these various strands of analysis, identifying the primary research objectives and questions addressed in the remainder of the thesis.

1.1: The agriculture-water interface: defining the problem.

Water is a vital resource, not only to the sustenance of human life itself but as an input into agricultural and industrial systems. It is also a vital element of the British landscape, with a rich diversity of dependent flora and fauna living in river corridors and wetlands. Water is in many ways a quite unique resource, as it is naturally renewable and reusable. New supplies of water become available each year through the natural water cycle, which can be supplemented by recycling and waste water renovation to increase supplies of 'second hand' water. In addition temporal and spatial imbalances can readily be adjusted through water storage and transport facilities, notwithstanding the potential which desalination offers for tapping the massive resources of the sea (Rees and Williams 1993). Nevertheless, the ability to directly intervene in the natural water cycle and artificially supplement supplies of water should not detract from the vital environmental processes which underpin the natural water cycle. The intricate interdependencies which link ground and surface water in a finely balanced relationship are vital to the maintenance of not only water quality and quantity, but also to wetlands and their ecosystems. Ground water naturally feeds surface water through springs and base flow to rivers, and in consequence, removal or even diversion of ground water can critically affect total river flow. A reduction in either the quality or quantity of the contributing ground water can also significantly influence the achievement of surface water quality standards (NRA 1992a). Surface water management also exerts a powerful influence over ground water. In particular the rate of surface water abstraction can damage environmental features such as wetlands, through depletion of the ground water base flow and maintenance of surface water flows is also vital to the protection of *in situ* flora and fauna and the dilution of pollution.

Water is a multiple use resource encompassing economic, social and environmental processes; vital to human life and as an input into industrial and agricultural systems, as well as supporting *in situ* dependent flora and fauna and pollution dilution processes. It is a complex and dynamic web of inter-dependencies which poses a number of complex questions for management, as changes in one sphere have a direct or indirect impact further downstream on the other users and uses of water. This is reflected in the integrated approach to the management of water resources, whereby the inter-dependence between ground and surface water, water quality and quantity is placed at the heart of policy, to ensure changes in one sphere do not have a negative impact on the other users and uses of water (O.E.C.D 1989; Mitchell 1990; NRA 1992a). This integrated management approach provides the starting point for instigating the sustainable development of water resources.

To date the academic and policy debate on sustainable water resource management has developed in a piecemeal way. Water quality and quantity have either been treated as separate and distinctive areas of policy, with little attempt to develop an integrated approach to water resource management (Postel 1992; Hanley 1993), or analysts have assessed policy against very narrowly defined criteria of economic efficiency (Dubourg 1993, 1995) and failed to assess the wider social or environmental impact. The most far reaching analysis, put forward by Rees and Williams (1993), suggests the sustainable management of water in the UK should not simply focus on the conservation of water today to ensure future supply availability. They argue this is meaningless as new supplies of water are continually being made available through the natural water cycle (Rees and Williams 1993). Instead, the critical question should focus on ensuring that the human use of water conforms to economic, social and environmental criteria of sustainability, encompassing the concepts of economic efficiency¹, social equity² and distributive justice. Critically, these authors

¹ Economic efficiency of water use implies the optimal allocation of available supplies between competing users and uses to insure the maximisation of total welfare derived from the resource; secondly, economic efficiency demands the development of least cost supply enhancement schemes only when the benefits derived from the additional supply exceed the costs involved.

² Social equity and distribution relate to the ability of customers to pay for water to meet their basic needs.

also recognise that intervention in the water sector should not undermine the sustainability of interdependent economic and environmental systems.

Agricultural systems are no less complicated, as agricultural policies evolve in response to specific economic, social, political and institutional forces of change (Marsden *et al* 1993). The land base on which agricultural production is so dependent is comprised of continually evolving environmental sub-systems. Intricate geo-chemical and geo-physical processes are central to the maintenance of the soil, breakdown of these delicate systems leads to erosion and leaching of soils for example, which in turn critically influences the productivity of agriculture (Conway and Pretty 1991). This economic and environmental system is closely inter-twined and subject to dynamic forces of change, with social change impacting on the ecological system and vice versa (Norgaard 1994). In fact, these ecological processes have been progressively harnessed and supplemented by human intervention, through the use of chemical inputs and mechanisation, resulting in the intensification of agricultural production systems. This process has had a significant impact on the natural environment, contributing to the loss of landscape, wildlife habitat, and dependent flora and fauna, as well as the pollution of ground and surface water sources (RSPB 1988, 1990; Conway and Pretty 1991). To date the debate on the sustainable development of agricultural systems has focused on the de-intensification of production to ensure the protection of the environment, through reform of the system of price support, introduction of alternative environmental taxes and subsidies, and the use of organic production methods (Hodge 1991). Nevertheless, it is recognised that the objective of environmental sustainability must be balanced against the economic and social sustainability of the rural economy, in which agriculture plays a vital role as a source of employment and income (Bowers 1995; Murdoch *et al* 1992).

Hitherto policy in the water and agricultural sectors has evolved quite separately with little consideration of the impact of social or ecological changes for inter-dependent economic or environmental systems. Nevertheless, the agricultural and water sectors are closely inter twined,

both economically and environmentally, as problems are displaced from one media to another. This is revealed most vividly in the case of diffuse pollution of ground and surface water sources. The agricultural price support system has resulted in the intensification of production with heavy reliance on chemical inputs. Inappropriate or over use of these chemicals results in leaching, whereby chemicals percolate through soil and rock strata and ultimately enter surface and ground water sources. This contributes to the decline of surface and ground water quality and thereby undermines the protection of *in situ* dependent flora and fauna. Agricultural policy is not directly concerned with these externalities of production, and responsibility for the resolution of these problems is shifted to other sectors of the economy, leaving unchallenged the system of incentives which underpins agricultural production. In consequence, Water Companies are in the process of investing millions in order to ensure water quality complies with EU Directives on drinking water quality (OFWAT 1992; 1993). A second example relates to improvements in the quality of UK rivers and coastal waters, which resulted from increased investment in sewage plant technology by the Water Companies (NRA 1995a; 1995b). Although these schemes have proved successful in improving the quality of water, secondary pollution problems have developed as a consequence which focus on the disposal of sewage sludge, with concerns developing over the safety of disposal methods to land sites and the sea (Davis 1993). Given these complex economic and environmental interdependencies it is vital to trace the impact of policy changes in agriculture on the water sector and vice versa to ensure unintended consequences and side effects do not perpetuate unsustainable practices, nor lead to more complex secondary environmental problems.

The analysis presented here will focus on one specific dimension of the agriculture-water interface, namely the allocation and regulation of abstraction water for use as spray irrigation by farmers. This reflects an emerging arena of conflict as farmers, primarily in the eastern counties of England, demand greater access to and use of reliable supplies of water for use as irrigation in the aftermath of the drought of 1989-92 (NRA 1994a, 1994b; Weatherhead *et al* 1994). Nevertheless, this is not a simple nor uncontested process as the Environment Agency, has to balance these demands against

the available supplies of water, the requirements of domestic and industrial water consumers, as well as maintaining flows to ensure protection of the *in situ* water environment and pollution dilution processes. The conflicts and contradictions inherent in the allocation and regulation of abstraction water between these competing users and uses, are becoming more sharply focused as existing supply sources become fully committed and potential new resource development sites are severely limited (NRA 1994a; NRA 1994b). Added to this, there is uncertainty over the impact of climate change on water resources, in terms of the effect on both the availability and demand for water (DoE 1996b; Parry and Duncan 1995).

In light of this, the Environment Agency has shifted the emphasis of policy to embrace the principles of demand management, which focus on improving the efficiency of existing water use patterns and reducing wastage. In theory, the implementation of demand management policies in the agricultural sector should conform to the economic, social and environmental criteria of sustainable water resource development. Nevertheless, there are a number of potential problems with such an approach. Firstly, the response of farmers to these policy measures is by no means certain, as demand management policies fail to take account of the wider regulatory forces influencing irrigation decision making. Thus, the response of farmers may be distorted, undermining the efficiency and efficacy of the chosen regulatory tool, leading to unintended environmental consequences and side effects which require further regulation. Secondly, although specific policy tools may succeed in shifting the use and management of irrigation water along a sustainable pathway, it is also possible they will perpetuate unsustainable agricultural practices (Rees and Williams 1993). Consequently, it is vital to explore the complex inter-sectoral dynamics shaping the agriculture -water interface, in order to expose and ameliorate the key forces perpetuating the dynamic cross media displacement of environmental problems.

Tracing the impact of environmental policy initiatives on inter-dependent economic and environmental systems, although vital, is by no means a simple task. A purely sectoral approach is

deeply ingrained within policy communities, as environmental policies are primarily geared to meeting specific environmental standards in specific sectors of the economy (Weale 1992; Majone 1989). Thus, policies are evaluated against very narrowly defined criteria and no consideration is given, in the pre- or post- implementation phase, to the direct or indirect impact on inter-dependent economic and environmental systems. Little consideration is given to the wider regulatory context within which the regulated are situated, and policy makers are therefore surprised when the target population fails to respond in the theoretically optimal manner (Jacobs 1994; Redclift 1992). In reality, specific environmental policy signals may be undermined or distorted by other direct and indirect regulatory signals, such as banking policies, EU subsidy programmes, local planning policies or national employment agreements. These direct and indirect forces of regulation impinge on and distort the formation of specific management responses to specific environmental regulations, and potentially undermine the efficiency and efficacy of the chosen regulatory tool. This is demonstrated in the case of the UK sewage discharge scheme, where a 400% increase in discharge fees over a five year period failed to induce any change in the behaviour of firms, despite the availability of technologies which would reduce discharges with a pay back period of one year (Pearson and Smith 1990). This economic signal failed, even though the fees were raised, because discharge costs were a small percentage of the firm's total costs and management time was therefore spent on achieving other savings.

An inter-sectoral approach cannot simply be confined to tracing the impact of policies on inter-dependent economic and environmental systems. This provides only a partial insight into the complex and dynamic processes at work, and leaves unchallenged the key forces which perpetuate the cross media transfer of environmental problems. Consequently, it is vital to adopt a broader approach, which exposes the combination of direct and indirect regulatory forces which together undermine and distort the response of the regulated to specific environmental policies and contribute to the dynamic displacement of environmental problems.

Central to this approach is the conceptualisation of the interface, which provides a key mechanism for linking together the complex and dynamic processes at work. Drawing on the work of Long (1989), the interface is defined as

“..a critical point of intersection or linkage between different social systems, fields or levels of social order where structural discontinuities, based upon differences of normative value or social impact, are most likely to be found. The concept implies some kind of face to face encounter between individuals, or units representing different interests and backed by different resources” (p1)

In light of this conceptualisation, the agriculture-water interface is clearly much more than simply the inter-section between divergent water and agricultural policies. Although these policy signals represent contradictory tendencies, they are also representative of different interests and values. The signals are the outcome of complex processes of interaction within and between institutions involved in directly and indirectly regulating the agriculture-water interface. Thus, the conflicts and contradictions which emerge reflect the interaction between different actors, asserting different values and drawing on different resources, in order to influence and shape the direction of change at the farm level in line with their own particular interests. Consequently, this analysis will not focus merely on the optimal design and implementation of demand management policies in the agricultural sector but also expose the conflict of interests and values which underpin the direct and indirect forces of regulation which impinge on farmers' irrigation decision making. This is revealed in figure 1.1 which explicitly identifies the principal forces of direct and indirect regulation emanating from the agriculture-water interface, encompassing not only the most obvious agencies such as the Environment Agency and MAFF but also supermarkets, the PMB, specialist irrigation equipment manufacturers and irrigation advisers.

Firstly, the restructuring of the organisational framework of the water industry, with the creation of the private Water Companies and a new environmental regulator, the Environment Agency, created a new agency with responsibility for the regulation of agriculture. The EA falls outside the

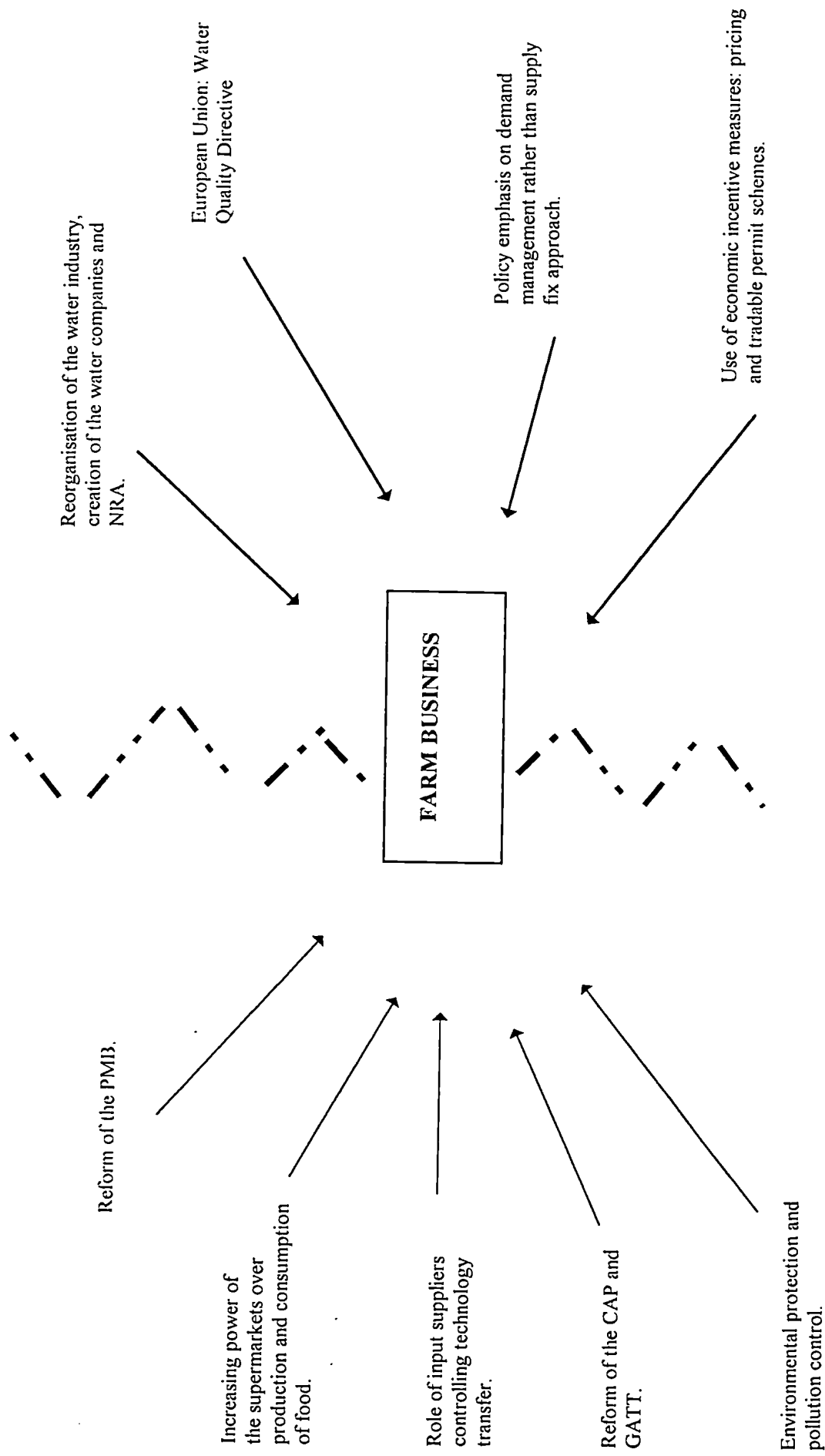


Figure 1.1 The key forces of regulatory dissonance at the agriculture-water interface

traditional structure of state involvement in agriculture, which is primarily channelled through MAFF and represents a new threat, as its policy remit directly challenges the status quo by focusing on the protection of the environment. Secondly, competition for access to and use of reliable supplies of water between the different users and uses is increasing, with limited new supplies available to meet this demand. Although the Environment Agency is actively examining the scope for alternative water supply sources, including the construction of new reservoirs and development of ground water sources, policy has shifted to embrace the principles of demand management. Demand management techniques target the existing pattern of water use and attempt to reduce wastage and improve the efficiency of water use. Central to this policy approach is the use of economic incentive measures (NRA 1994a, 1994b), which increase the cost of water and should in theory encourage conservation. This represents the third major change in policy in the water sector which will have a profound impact on farmers' use and management of irrigation water. Finally, the EU also plays a direct role, most obviously through the Directive on Drinking Water Quality, and the proposed Directive on water resource management will play a major role shaping the future direction of Government and Environment Agency policy.

In the agricultural sector, regulatory restructuring has also led to significant changes. The 1993 GATT agreement led to significant reform of the CAP, and culminated in the price support system shifting the emphasis away from production *per se*, to the protection of farm incomes and the environment. In consequence, a number of new initiatives has been developed under both MAFF and the EU which attempt to encourage diversification schemes on the farm, as well as specific schemes to protect the environment such as the Environmentally Sensitive Area and Countryside Stewardship schemes. Nevertheless, state regulatory agencies are not the sole influence on farm management as firms from the up and downstream food system play a significant role, indirectly penetrating on-farm production decision making. Input suppliers such as chemical and seed manufacturers play a key role channelling technological change at the farm level (Hawkins 1991),

while food manufacturers and processors exert a powerful influence ensuring the quality of produce. Of increasing significance is the role of the supermarkets in regulating on-farm production (Flynn *et al* 1994), as they capitalise on their position of power within the food system to manipulate the production and processing of food to conform to their own quality standards. Thus, a plethora of public and private, national and international agencies potentially exerts a powerful influence over on-farm irrigation decision making. Exposing the form and function of these influences is critical, in order to understand the response, and more importantly non response, of farmers to demand management policies, and the unintended consequences and side effects which result.

1.2: Disentangling the problem: conceptualising regulation.

A number of divergent national and international, public and private sector agencies all play some part in regulating farmers at the local level, and it is therefore vital to explicitly identify the key processes at work. The first step in disentangling this complex web of inter-dependencies is the development of a coherent conceptualisation of regulation, in order to link together the multiple layers of direct and indirect regulation which in combination shape and influence the use and management of irrigation water.

Regulation is in many ways a quite elusive concept to define precisely. Definitions reflect not only the inherently ideological nature of the concept which demarcates the role of the state and market in society, but can also incorporate precise definitions which focus on policy instruments and legal rules (Hancher and Moran 1989). In consequence there is a plethora of competing definitions and it is almost impossible to pin down a precise definition as it is a metaphor for a number of social practices (Leyshon 1992). This is further complicated by the process of de-reregulation which critically reshaped the form and function of state intervention throughout the 1980s and early 1990s. The dual processes of deregulation and privatisation were instigated by the Thatcher Government in an attempt to divest the state of key areas of responsibility and ensure the operation of the free

market. Nevertheless, despite the rhetoric, the process of deregulation was in practice, a much more complex process than initially implied. The conceptualisation of deregulation as the mirror image of regulation implies the removal or relaxation of previous rules and legal guidelines. This, however, is too simplistic and fails to grasp the complexity of the process, as Cerny (1991) reveals how deregulation is in fact accompanied by a dual process of re-regulation, whereby existing state regulations are replaced by new legal rules or regulatory instruments. In the UK this has led to the legitimisation of regulatory forms which blur the distinction between the public and private sectors (Lowe *et al* 1994), with the state divesting itself of key responsibilities to private sector organisations. This process is evident in the food sector, where the state has succeeded in partially disengaging from the direct regulation of food safety and quality with responsibility shifted to the food retailers (Flynn *et al* 1994), and their position within the food system has been formally sanctioned and legitimated by the State.

The process of de-reregulation has succeeded at the national level in shifting responsibility for key areas of state regulation to private sector organisations. Running in tandem to this process, the state has also been superseded by international systems of regulation, which are encroaching on traditional areas of state responsibility. In particular, the European Union is an increasingly significant player in domestic policy, with new Directives and Agreements emanating on social, economic and environmental issues. These policies are legally binding and over-ride existing state policies, which in turn are leading to massive investment by Government and industry to ensure compliance (see OFWAT 1992, 1993 for example). These agreements nevertheless, are only the tip of the iceberg, as the state is a signatory to a wide number of international agreements; for example the new GATT agreement signed in 1993 and the Rio Declaration of 1992. These agreements have profound implications for Government policy at both the national and international level; the GATT Agreement sets out the key areas of reform to ensure free trade, while the Rio Declaration sets out the timetable for the achievement of key environmental targets. At the national level these agreements have been translated into a plethora of new rules and regulations which have contributed

to the increasing complexity which characterises the regulatory process. Thus, it is too simplistic to conceive of deregulation as the removal of existing rules and legal guidelines, as the deregulatory process has shifted responsibility for key areas of policy either down to the private sector or upwards to international organisations. In consequence, the 1980s and 1990s have not witnessed an end to regulation, but a significant restructuring of its form and function. As Ayres and Braithwaite (1992) argue

“We have not, and are not, experiencing an era of deregulation so much as an era of regulatory flux - an era where dramatic regulatory, deregulatory and re-regulatory shifts are occurring simultaneously” (p7)

This process of regulatory flux or restructuring poses clear problems for the regulated, as they are increasingly caught up in a regulatory network which is undergoing a process of change. Competing and conflicting signals are emanating from various national and international, public and private sector agencies which are pushing and pulling them in different directions. In consequence, the formation of a specific response to a state policy initiative by the target population is no simple task, as this signal may be distorted by other direct and indirect forces of regulation. In fact, these forces of regulation may over-ride a specific state policy, and consequently the regulated will fail to respond in the expected manner, leading to unintended consequences and side effects.

The process of regulatory restructuring exposes the disjunctures between national and international, public and private forces of regulation. This is translated at the local level into increased levels of dissonance, as the signals relayed by specific state regulatory tools in one policy field conflict with or contradict the signals transmitted by other direct and indirect forces of regulation. This is illustrated in the agricultural sector, where the breakdown of the agricultural productivist model, reflected in the reform of the CAP, as well as the restructuring of rural areas in general, means that farmers stand at the apex of divergent processes of change. On the one hand these forces are encouraging specialisation and farm concentration, while on the other encouraging diversification and pluriactivity. These dual processes in combination are providing opportunities for increasing

amounts of dissonance between nation states and between policy makers and farmers (Marsden *et al* 1992; Marsden and Murdoch 1990). Hence, it is critical to avoid conceptualising regulation merely as the preserve of either the state or market, as this confines analysis to a very limited set of questions which diminish the importance of the other critical social, political and market forces which together play an important role in all stages of the regulatory process. As Grabosky (1996) argues

“The fact that state regulatory agencies do not exist *in vacuo* , but rather in a framework of mutually constitutive interaction with non-governmental institutions and actors, suggests that to focus on a single institution, in what ever sector, gives one a very limited perspective on the regulatory process” (p202)

Adopting a broad conception of regulation to include public and private sector actors goes some way towards unpacking the complexity which characterises the process of regulation. Implicit in this approach is the recognition that regulation is an inherently social practice (Clark 1992) which draws together analyses from the sociological and political economy traditions (Lowe *et al* 1994) to enable recognition of the multiple layers of state, market and social regulation within which the regulated are situated.

1. Market forces of regulation.

Market forces of regulation exert a powerful influence, directly and indirectly shaping the production and consumption decision making of consumers by price and quality information, as well as through the images portrayed in advertising campaigns. Companies also exert considerable power and influence over each others behaviour (Grabosky 1996), as they are also significant purchasers of goods and services in their own right. Thus, the interchange between buyers and suppliers in the market place is a significant force of regulation as firms exert considerable pressure on each other in the quest to maintain market position (Levacic 1991; Krizner 1991). Contracts of agreement with suppliers enable the purchasing firm to stipulate the product specification, quality criteria and delivery date, as well as negotiate the price level. This serves to regulate production as the supplier must ensure production meets the buyers' specification.

Economic theory identifies the mechanisms through which firms organise production in order to maximise efficiency under pressure from shareholders, creditors and consumers to ensure the minimisation of production costs (Ogus 1994; Demsetz 1988; Eggertsson 1990). Companies can instigate measures to improve their efficiency such as inventory, price and employment practices. These internal processes of regulation serve to influence, channel or redefine the position of the firm in the market place and thus influence the behaviour of those who populate the firm's market (Balch and Wu 1974). Large retailers command significant positions of power as they are able to exploit their purchasing power in order to dictate the quality, price and delivery date for produce. Suppliers to large retailers and manufacturers are subject to intensive scrutiny of their production and manufacturing processes to ensure buyers are not tainted by the suppliers' questionable production process (Grabosky 1996). In fact, Grabosky (1996) documents how large retailers are instigating programmes which scrutinise products from the cradle to the grave, to evaluate the environmental costs of the product. This process of product assessment is critical as it sends important signals to the market place. If companies defy these signals or fail to meet the requisite standards they run the risk of losing their competitive edge and, by implication, their market position.

2. Social forces of regulation.

The regulated are by no means passive recipients of change; through membership of interest groups they actively influence all stages of the regulatory process. Spontaneous campaigns against particular state policies or business practices can lead to radical actions by a range of social groupings, the most recent example being the campaign against live animal exports in 1995. Apart from these direct action campaigns, which have very limited involvement or engagement with Governments at the national and international levels, other more established producer and consumer groups have a direct line of communication to government. Representative bodies such as the National Farmers Union (NFU), Confederation of British Industry (CBI) and British Retail Consortium have a direct influence over the design and implementation of Government policies.

The success of these organisations in negotiations and representations to Government is dependent on the degree to which they involve themselves in the self regulation and discipline of their own constituency (Cox *et al* 1985). These relationships have been dubbed “corporatist” by commentators which is defined as

“..a mode of policy formation, in which formally designated interest associations are incorporated within the process of authoritative decision making and implementation” (Schmitter 1981, p295).

The relationship of the NFU with Government has been cited as the classic example of corporatism (Cox *et al* 1985; Grant 1983) as agricultural producer interests are entrenched in all stages of the policy process; from the definition of a policy problem, to the design and implementation of policy tools. Nevertheless, in the post-productivist period the position of the NFU is under stress, as consumer and environmental interests dominate the political agenda (Lowe *et al* 1994). As Flynn *et al* (1994) argue this process of change is re-defining the relationship of the NFU with Government, as other consumer interests, primarily food retailers, are incorporated into the policy process, giving rise to new forms of micro-corporatism. Interest groups are key actors in the regulatory process as they mediate between Government and their own members acting as a channel of communication. These groups play a pivotal role as they succeed in not only (re)educating Government of their supporters’ problems, but also play a key role in educating and policing their own constituency.

3. State forces of regulation.

The role of the state in the process of regulation has dominated academic and policy discourse (Cerny 1990; Hahn and Stavins 1991; Yandle 1989) with an emphasis on the design of the optimal tools and instruments of state intervention. The state can harness direct and indirect mechanisms to regulate social and economic development through direct state ownership and planning, direct state regulation through command and control style standard setting, indirect use of economic incentives

such as taxes and pricing schemes, and finally indirect measures of social regulation which involve the use of information, education and persuasion to change value systems and behaviour (Rees 1992). These mechanisms are by no means mutually exclusive and a combination of tools may be used in a specific regulatory space (Eckersley 1996; Jacobs 1996).

The implementation of state regulatory tools rarely conforms to the theoretically optimal schemes designed by policy analysts (Majone 1989). Political and institutional constraints critically influence and colour the design and implementation of state regulatory tools, as alternative regulatory instruments critically alter the position and power of various policy actors within state institutions. Thus the design and implementation of state regulations are rarely uncontested or neutral processes, with conflicts of interest and values occurring within state institutions. In consequence, as Clark (1992) argues in his analysis of 'real' regulation, it is critical to focus on the actual administrative manner, style and logic through which the state regulates society. By re-focusing analysis on the actual institutions of state regulation, it is possible to identify the real conflicts of interest and values which evolve in all stages of the regulatory process; not only within the state institutions but also in the interaction between state, market and social forces of regulation.

This conceptualisation of regulation ensures movement away from simple one-dimensional analyses of the design of state regulations or role of interest groups, which are replaced by an alternative, broad based approach which emphasises the interaction and interdependence between direct and indirect state, market, and social forces of regulation. Through recognising that regulation does not occur in a vacuum, but is linked to an inherited set of social norms and practices, it is possible to open up to analysis the multiple layers of regulation which directly and indirectly influence the behaviour of the regulated, and contribute to the dynamic displacement of environmental problems.

1.3 The agriculture-water interface: the research objectives.

The conceptualisation of regulation provides a critical point of entry into understanding the complex and dynamic processes shaping the agriculture-water interface. Distinguishing the direct and indirect forces of state, market and social regulation ensures the transparency of the combination of processes which together influence irrigation decision making, and the unintended consequences and side effects which result. It enables analysis to move beyond simply focusing on one specific dimension of state or market intervention and instead to emphasize the dynamic interaction between these divergent forces of regulation. Consequently, this analysis sets out with the overall aim of exposing the combination of regulatory forces which together undermine and distort the management and use of irrigation water. Four specific objectives are identified, and focus on the multiple layers of state, market and social regulation at the agriculture-water interface.

- What are the key influences shaping the form and function of state intervention at the agriculture-water interface? What constraints do the policy makers work within, and how does this influence the policy process, from the conception of the problem, through to the design and implementation of the policy tools?
- What are the principal forms and functions of market forces of regulation at the agriculture-water interface? How do off-farm firms directly and indirectly shape and influence farmers' irrigation decision making, and what are the implications not only for the on-farm use and management of irrigation water but also for the introduction of demand management policies?
- How influential have farmers and their representative organisations been in shaping water abstraction policy? How did they respond to the drought of 1989-92, and what can this tell us about the ability of the NFU and CLA to deal with new and emerging environmental problems?
- What is the impact of this regulatory dissonance on farmers' irrigation decision making? How do farmers trade off and reconcile these competing and conflicting signals in order to formulate effective farm management strategies?

These research objectives address different facets of the agriculture-water interface problem, and should enable the analysis to expose the combination of processes which together contribute to the unintended environmental consequences and side effects which result from policy intervention.

1.4 Conclusion

This chapter has established the key parameters of the agriculture-water interface problem and in the succeeding chapters of this thesis the analysis will explore its multiple dimensions. The chapters are organised to ensure the transparency of the combination of state, market and social forces of regulation shaping the agriculture-water interface. Two levels of analysis are differentiated.:

1. relating to the form and function of state, market and social forces of regulation at the agriculture-water interface, and the mechanisms through which these regulatory forces shape and influence irrigation decision making at the farm level.
2. focusing on how farmers themselves respond to these competing regulatory signals, and the implications not only for their use and management of irrigation water but also their potential response to demand management policies.

The analysis of the complex and dynamic set of inter-relations which characterise the agriculture-water interface poses a number of complex analytical and methodological questions, which are directly addressed in Chapters Two and Three. Drawing together the literatures from economics, politics, sociology and geography, Chapter Two examines the alternative theoretical conceptualisations of the nature-society relationship. The review concludes that no single disciplinary perspective provides an overarching theoretical framework for analysis, and in reality elements from each of the different perspectives are potentially useful. Six theoretical postulates form the basis of an alternative theoretical framework of analysis. Chapter Three concentrates on methodological questions focusing in particular on the interface-network approach. This forms the basis of the empirical strategy which is outlined in detail, and the chapter finally concludes with a brief examination of the methodological issues raised in the analysis of the empirical material.

The state and social forces of regulation governing the water and agricultural sectors are examined in Chapter Four, where the analysis concentrates on the detailed exploration of the political, institutional and administrative factors shaping the design and implementation of state policy at the agriculture-water interface. Detailed scrutiny of the institutional framework governing the allocation and regulation of water in the UK will explore the past and present role of vested interests in

shaping the direction of water abstraction policy. The analysis identifies the critical constraints within which the water regulators operate, which serve to undermine their powers to effectively protect the environment. The shift in emphasis away from supply towards demand management policy is explored, and the analysis outlines in detail the specific implications for the use and management of irrigation water.

Chapters Five and Six concentrate on the presentation of the empirical analysis, with Chapter Five focusing on the network of market forces of regulation which directly and indirectly influence farmers' use and management of abstraction water. The analysis documents the organisational structure of the network of relations which link supermarkets with the producers of fresh fruit and vegetables, and the forces of direct and indirect regulation which enable them to control production at the farm level. The impact of these regulatory forces on both the on-farm use and management of irrigation water and the introduction of demand management policies are clearly documented. The chapter concludes by outlining the central role of the downstream food network in implementing demand management policies in the agricultural sector.

Chapter Six draws together the analysis of the state, market and social forces of regulation by focusing on farmers' interaction and engagement with these divergent regulatory forces. The analysis explores how farmers, both individually and collectively, respond to these divergent forces of state and market regulation, in the context of their management and use of irrigation water. By focusing on farmer's interaction with both the EA and the downstream food network, it is possible to identify the key forces influencing irrigation decision making and the implications for the design and implementation of demand management policies. Chapter Seven, the final chapter, will attempt to pinpoint the central conclusions, not only for the theoretical debate on the integration of the environment and economy, but also the key issues for environmental policy and practice. The analysis will identify the implications for the future regulation of the agriculture-water interface, and suggest an alternative agenda of action for the Environment Agency.

CHAPTER TWO
CONCEPTUALISING THE AGRICULTURE-WATER INTERFACE:
ALTERNATIVE FRAMEWORKS OF ANALYSIS

The conceptualisation of the agriculture-water interface developed in Chapter One accentuates the dynamic interaction between two inter-dependent economic and environmental systems, and pinpoints the problems which these processes pose for environmental policy and the quest for sustainable development. The primary aim of this chapter is to set out an analytical framework which links together the combination of processes which directly and indirectly shapes and influences the integration of the environment and economy, to reveal the unintended environmental consequences and side effects which result.

This chapter is divided into three sections and the first section will concentrate on refinement of the research objectives. The analysis will underline the central dimensions of the nature-society relationship, which are central to analysis of the agriculture-water interface. Drawing on the environmental policy and management literatures, the analysis will reveal the failure of these approaches to directly address the key inter-sectoral dynamics shaping the agriculture-water interface. This establishes the foundation stone for the second section, which will examine the relevance of key alternative theoretical approaches found in sociology, politics, economics and geography to understanding these complex and dynamic inter-relations. Analysis of these competing conceptualisations reveals that on their own they provide only partial insights into the dynamic processes at work, underlining the need for a new, alternative approach. The final section concentrates on the development of this alternative analytical framework. Avoiding the confines of specific models, theories and disciplinary perspectives, the analysis will identify six theoretical postulates, which together address different dimensions of the agriculture-water interface problem.

2.1: The key dimensions of the nature-society relationship.

The characterisation of the agriculture-water interface developed in Chapter One underlines the vital importance of adopting an inter-sectoral approach to environmental policy and analysis. Such an approach ensures not only the transparency of the combination of processes influencing the response of the regulated to specific environmental policies, but also reveals the dynamic processes underpinning the displacement of environmental problems from one media, time or place to another. To date policy discourse has focused purely on the design, implementation and assessment of environmental regulations within specific sectors of the economy and ignored the impact on interdependent economic and environmental systems. This failure reflects the simple, technocratic model which has dominated environmental policy making since the 1970s (O’Riordan 1976), where the environment is conceived as a static system, in which there are no dynamic inter-linkages between key environmental sub-systems. In consequence, policy develops in an ad hoc fashion dealing with the symptoms of environmental pollution or degradation as they arise in specific environmental media (O’Riordan 1976; Majone 1989; Weale 1992; Janicke 1990). This largely reactive strategy fails to develop a clear understanding of the underlying causes of the environmental problem and consequently focuses on technical, end-of-pipe policy solutions.

The problems associated with such an approach are clearly distinguishable in the classic example of air pollution control, where policy in the UK was directed to the construction of high smoke stacks to resolve the problem of fog and smog in industrial areas. This policy development, while resolving the particular problem in the UK, also resulted in the displacement of problems to other media, times and places (Janicke 1990; Weale 1992). Hence Germany and Scandinavia suffered extreme problems as a consequence of sulphur deposition or acid rain, with destruction of forests, pollution of lakes and loss of wildlife becoming increasingly prevalent from the early 1970’s (see Newbery 1990; Park 1987). The short term technical fix approach to environmental policy in this field only provided a partial resolution of the problem, while in turn creating far more complex cross-media environmental problems. As Weale (1992) recognises, cross-media transfers are an

intrinsic feature of any pollution control system, as resolution of one issue creates significant secondary problems which require further regulation. Thus, the technocratic model which dominates policy in fact perpetuates and increases the complexity of environmental problems. Failure to address the complex and dynamic inter-dependencies and interactions not only between environmental sub-systems but also between the environment and economy, leads to a self-perpetuating cycle of incremental policy reform.

Environmental policy analysis has itself replicated this technocratic approach and left unchallenged some of the key assumptions of the model. Majone (1989) argues that policy analysts in the environmental field have focused purely on technical issues, such as the optimal design of regulatory tools to achieve specific environmental objectives (Tietenberg 1991; Hanley 1993; Hahn and Noll 1982; Hahn and Hester 1989); or the assessment of environmental regulations against narrowly defined criteria of efficiency or equity (Auld 1985; Baumol and Oates 1975; Johnson et al 1990). Although specific environmental regulations within specific sectors of the economy may prove successful in achieving narrowly defined targets, assessment will not reveal the secondary problems which also develop (Weale 1992). Thus policy analysts largely ignore the implications of specific environmental regulations on inter-dependent economic and environmental systems, and the dynamic displacement of problems to other media, times or places.

It is vital to break away from this technocratic approach and develop an alternative perspective for analysis of the agriculture-water interface, which does not simplify or marginalise the complex and contradictory processes at work. Analysis must shift, to address the combination of processes which together undermine and distort the integration of the environment and economy. Central to this approach is the conceptualisation of regulation developed in Chapter One. Explicitly identifying the multiple layers of state, market and social regulation enables analysis to expose not only the key processes shaping the form and function of intervention within these institutions, but also the key forces distorting interaction between them. This approach also ensures the transparency of the key

forces shaping the behaviour of the regulated, providing critical insight into understanding their response or more importantly non response to specific environmental policy signals, and the unintended consequences and side effects which result. Thus, the analytical framework must focus on five different levels, which include:

- (i) farmer interaction with state, market and social forces of regulation and the implications for irrigation decision making;
- (ii) the key processes shaping the design and implementation of state water and agricultural policy;
- (iii) the form and function of market forces of regulation and the implications for the use and management of irrigation water and the water environment;
- (iv) the influence of social forces of regulation over both the use and management of irrigation water at the farm level, and the design and implementation of water policy,
- (v) the dynamic processes of interaction and inter-linkage between these different forces of regulation, and the implications for the integration of the environment and economy.

These different levels of analysis address different dimensions of the agriculture-water interface problem and form the foundation stone for the theoretical framework. In order to progress, it is vital to examine alternative conceptualisations of the nature-society relationship found in geography, sociology, politics and economics, to evaluate their relevance and applicability in understanding the form and function of these complex and dynamic inter-relations and the implications for the integration of the environment and economy.

2.2: Competing conceptualisations of the nature-society relationship.

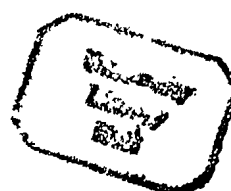
There are a plethora of alternative frameworks of analysis from economics, politics, sociology and geography which offer competing conceptualisations of the role and significance of nature and society in development. Drawing on alternative market and state failure theories, different economic, social, political and institutional processes are variously emphasised in explaining the decision making and behaviour of individuals, firms and Governments towards the environment. These frameworks draw on competing ethical principles concerning how, and to what extent, environmental costs should be avoided and/or allocated to current and future generations across different geographical scales (Eckersley 1996).

This section will critically evaluate the relevance of these different approaches to understanding the complex and dynamic inter-relations shaping the agriculture-water interface. Six different approaches or frameworks of analysis are explored. The neo-classical welfare economics approach, which dominates environmental policy discourse, is the starting point for this analysis. The following sections then concentrate on the political science perspective, including the theory of state failure, the behaviourist approach to decision making, and the political economy and political ecology traditions, with their emphasis on the dynamic relations of power and dependence, which enable and constrain the behaviour of individuals, firms and Governments.

2.2.1: The neo-classical, welfare economic approach to the environment.

Economists have played a critical role in recent policy and academic debates on the integration of the environment and economy and the quest for sustainable development. Although the central arguments were developed in the scarcity debates of the 1960s, environmental economics has been reinvigorated especially since the influential Pearce Report in 1989. The policy debate has been largely dominated by the neo-classical welfare economics approach, but new resource and ecological economists have also developed alternative, radical critiques (see for example Daly 1992; Baden and Stroup 1981; Simmons and Baden 1984; Anderson 1986). These approaches, however, have had limited impact in the UK, with the new resource economics approach largely confined to a small number of right wing research institutes in the USA.

The application of the principles of welfare economics to the environment does not differ markedly, in its approach or theoretical assumptions, to those used in the analysis of other economic policy problems. In line with standard welfare economics theory, markets 'fail' to take into account the full environmental costs and benefits of economic activity, as environmental goods and services are not properly valued. Hence, the environment is considered a 'free good' and is not properly incorporated into the decision making framework of firms and individuals, thus leading to its over exploitation and degradation. In order to resolve this problem, welfare economists suggest



that Governments directly intervene to correct market failure through imposing taxes or charges, forcing individuals and firms to internalise the full environmental costs of their production and consumption decision making.

Welfare economists attempt to turn the environment into a commodity which in turn can be analysed in exactly the same way as other commodities traded in the market. Nevertheless, this is not a simple nor unproblematic process, and is underpinned by a number of key theoretical assumptions. Explicitly outlining these assumptions provides critical insight into the way in which the nature-society relationship is conceptualised and, in consequence, highlights the limitations of the approach. Methodological individualism is the cornerstone of the welfare economics approach, in which economic activity is conceived solely in terms of individual behaviour. Thus, the environment is broken down into its constituent goods and services in order to ensure consumption by individuals. These individuals, so called 'rational economic persons', are assumed to behave in a self-interested and consistent manner in order to maximise their utility. It is then assumed that individuals operate in competitive markets, where they are able to exercise free choice. The role of markets are critical as they are assumed to tend towards an equilibrium point which enables the "optimal" or most efficient allocation of resources for society as a whole. Technology, however is conceived as exogenous to the economic system, and is therefore not the object of analysis. In combination with the equilibrium assumption, this creates an essentially static conceptualisation of the nature - society relationship where the world is perceived as reversible.

This theoretical framework provides the justification for the two main areas of analysis by welfare economists (Jacobs 1994). The first area of analysis focuses on the construction of supply and demand curves to determine the appropriate level of environmental protection. The supply curve is relatively simple to construct and requires information on the direct and indirect costs of environmental protection and the opportunity costs of economic activity foregone. The demand curve, in contrast, proves more difficult, as estimates must indicate consumers' 'willingness to pay'

for various environmental commodities. As no real markets exist for these commodities it is necessary to impute the prices, through hedonic pricing¹ or contingent valuation² techniques. There are a number of methodological and ethical problems associated with these techniques (see Sagoff 1988; Gower 1992; Blaikie 1995 for a full account), bringing into question the validity of the results which are used to indicate the optimal level of environmental protection.

The second group of analysts in contrast, focus on the most appropriate tools for achieving the pre-defined level of environmental protection. Although this links into the work of the first group of analysts, it can in fact stand alone as not all welfare economists agree economic techniques are the most appropriate way of determining environmental protection levels (Jacobs 1994). The analysts focus purely on the most efficient measures for ensuring the optimal level of environmental protection including the use of green taxes, pollution charges, tradable permits and incentive pricing techniques. These alternative regulatory tools are used to internalise environmental costs into individuals' and firms' decision making processes.

The environmental economics framework provides only a partial representation of the complex nature-society relationship. Notwithstanding the largely ethical and moral questions posed by commodifying the environment, two fundamental criticisms are levelled against the welfare economics approach which are particularly relevant to analysis of the agriculture-water interface. Firstly, the assumption of rational economic person does not provide an adequate or rigorous conceptualisation of individual decision making processes (Jacobs 1994). Real world decision making rarely conforms to this rational ideal and in consequence it fails to adequately explain the conflicting and contradictory responses of individuals to environmental policies. In fact, the social,

¹ Individuals willingness to pay for environmental goods are revealed through their demand for goods which in some way are associated with the specific environmental service in question. For example, the demand for a beautiful landscape is revealed through calculating the costs individuals incur travelling to look at it.

² Individuals are asked through a survey, to place a value on a specific environmental commodity by revealing their willingness to pay, or willingness to accept compensation for, protection or loss of specific environmental goods and services. For example the willingness to pay for the protection of the Blue Whale.

cultural, political and institutional context within which individuals are located is largely ignored, but as chapter one argued, these factors are critical as they all impinge on and distort the reaction of individuals to environmental policy signals.

The second point of criticism questions the relevance, to real world environmental conflicts, of the reversible equilibrium postulate. This static conceptualisation of society ignores the role and impact of changing technologies and values on the way in which individuals behave in markets and towards the environment. The fact that these processes change over time, prevents movement towards the so called optimal equilibrium position as dynamic social and economic changes constantly shift the equilibrium point. The extension of welfare economic analysis to environmental conflicts also replicates this mistake, by conceiving of the environment as a static system. Environmental systems rarely reach equilibrium positions and changes which occur are often irreversible (Redclift 1988; Jacobs 1994). In fact environmental systems represent highly complex and dynamic interacting sub-systems, interconnected by complicated geo-chemical and geo-physical processes, as Redclift (1988) argues

“..the properties of ecological systems run counter to those of what Norgaard (1985) terms the ‘atomistic - mechanical’ world view of neo-classical economics. Economics is not adapted to consider total changes. Resting as it does on the concept of the margin, it is epistemologically predisposed towards a reductionist view of resources and their utility” (p55).

Thus by focusing on the division of the environment into its constituent goods and services, welfare economists rarely examine the dynamic interaction and inter-dependence between environmental sub-systems. Analysis is forced to examine discrete problems in specific environmental media and in consequence prevents the development of an holistic approach which traces the dynamic displacement of problems to other media, times or places. Although this problem is partially addressed in the emerging field of ecological economics (see Daly 1992) it still fails to provide a convincing framework of analysis, as the welfare economic approach provides little insight into the key dimensions of the agriculture-water interface problem identified in section 2.2.

2.2.2. The tragedy of the commons approach on the environment.

The tragedy of the commons model is recognised as one of the central themes of environmental studies (O’Riordan and Turner 1983; Godwin and Shepard 1979) and epitomises the public choice perspective on property rights and externalities. Hardin’s seminal article in 1968 drew heavily on the work of Coase (1960) and the theory of externalities (Demsetz 1967) and consequently the limitations of these approaches are replicated in the tragedy of the commons model.

The tragedy of the commons model conceives of resources as appraised by atomistic individuals constrained in their choice by the dominant property right institution. Using the example of common land used by herdsmen, Hardin (1968) argued

“Picture a pasture open to all. It is to be expected that each herdsman will try and keep as many cattle as possible on the commons. As a rational being each herdsman seeks to maximise his gain “ (p1244).

He goes on to argue that even when the carrying capacity of the common land is exceeded, each herdsman will continue to add stock because he receives all the gains from the sale of the additional animals but shares only a fraction of the costs of the resulting over-grazing. Thus he argues for the privatisation of common ownership to force individuals to internalise the full cost of their resource use. Property rights are perceived as the central relationship defining the role of the state, market and individual, in the allocation of scarce resources. Drawing on the public choice perspective, the commons model focuses on the proposal that all environmental decisions should be made through bargains struck between actors in the market place, removing the need for state intervention through taxes or charges to correct market ‘failure’. Thus, property rights to the environment must be properly defined and enforceable, ensuring external costs and benefits, pecuniary and non-pecuniary externalities, are internalised or incorporated into the decision making framework of individuals, thereby conforming to the optimal and efficient allocation of resources. This article provoked a protracted debate on the relative costs and benefits of private as opposed to public or

common ownership (see Ciriacy-Wantrup and Bishop 1975; Dahlman 1980; McKay and Acheson 1988 for example). The theoretical and empirical limitations of the model have been well documented (see for example Dasgupta 1982; Bromley 1991) and cite the strong social institutions in force at the local level which regulate access to and use of the commons, successfully preventing their over use and degradation.

The tragedy of the commons models provide only a very limited insight into the complex and dynamic processes underpinning the displacement of environmental problems to inter dependent economic and environmental systems. Focusing analysis solely on the role of state and market institutions in regulating behaviour, these approaches fail to recognise the critical role of social forces of regulation in managing access to and use of environmental resources. Evidence indicates that collective systems of management ensure protection of key environmental resources with established rules and procedures to minimise conflict. The undue emphasis on 'rational' decision making ignores the interaction and interdependence between collective and individual responses to environmental-resource conflicts, and the way in which other objectives and goals influence the management system.

While not disputing the fact that a number of problems at the agriculture-water interface result from poorly defined and enforced property rights, this response on its own is insufficient to rectify particular environmental problems. Reform of the property rights system does not represent a once-and-for-all setting of access rights, as dynamic social and ecological processes will in combination ensure that, over time, the system will produce externalities or unintended consequences which require further state intervention. In fact by failing to take into account the other state, market and social forces of regulation which directly and indirectly impinge on individual decision making processes, analysts ignore how the specific environmental and economic signals reflected in the property rights may be distorted.

2.2.3: The political science approach to the environment.

The dominant economic approaches to the environment offer only very limited understanding of contemporary environmental - resource conflicts and the problems posed by the integration of the market and environment (Jacobs 1994). By focusing exclusively on the design and implementation of the optimal tools of environmental regulation, economists ignore the wider social, political and institutional context within which environmental policy operates. In the real world green taxes, charges and subsidies rarely conform to the ideal or optimal schemes described in the text books, as these policy tools are often distorted in the design and implementation process. The choice of regulatory tools is not simply a technical issue, nor an ideologically neutral process, but raises critical social, political, institutional and moral questions which are ultimately resolved by political measures (Majone 1989; Andersen 1994).

The political science literature provides key insights into the processes which influence and distort the integration of the market and environment, with its emphasis on the role of state institutions, policy styles, political bargaining processes and interest group intermediation (Schnaiberg 1980; Vogel 1986; Richardson and Jordan 1979; Lowe and Goyder 1983). Central to these analyses is the rejection of the notion of the state as a unitary body, working in a rational, ordered way to serve consistent, clear, public interest objectives. Instead policy outcomes are conceptualised as the product of interdepartmental power politics, where regulators are susceptible to manipulation and capture by powerful vested interests. Drawing on these different schools of analysis enables examination of the role of the state, and its institutions, in fostering or impeding the integration of the economy and environment, and is vital in understanding the forces of state and social regulation which directly and indirectly shape the agriculture-water interface.

The first key area of analysis focuses on the role of interest groups, where there is an established body of literature on interest group intermediation with the state (Cawson 1977; Schmitter 1981; Marsh 1986) and the development of corporatist relationships. Interest groups do not participate in

the decision making process on equal terms, as some are placed in a better position than others as a consequence of better access to the decision makers, bargaining skills, links to the media, money and access to information to manipulate the course of events around them (Rees 1990). The development of corporatist relationships between state institutions and interest groups enables some groups to gain easy access to the decision making apparatus, where they are consulted on the form and function of policy, while others are excluded from direct involvement. The power and influence of interest groups will vary depending on their legitimacy, the resources which they command in terms of people, money and information, and the degree to which they control their own constituency (Cox *et al* 1985; Cox *et al* 1987). This asymmetrical bargaining power is critical in shaping the policy discourse, as certain groups are able to capitalise on their position and exert considerable influence to ensure the protection of their interests.

External interest groups are not the sole force working to influence and shape the policy process; policy makers themselves are not neutral or benign decision makers. Work dating from the 1950s reveals the key processes which influence the decision making process, focusing in particular on the actual power and influence of actors within state institutions (Simon 1947, 1955; Lindblom 1959; Downs 1967; Perlman 1976). Perlman (1976) suggests individuals become focused on maintaining or enhancing the organisation as a whole by increasing its budget or size, while Downs (1967) argues individuals need to enhance or protect their position within the organisation. Thus, they become caught up in scoring points over other bureaucracies in order to ensure their own long term survival, and the development of their own organisation's prestige and influence. Organisations also attempt to retain a monopoly over information and its use, to ensure their own interests are protected and consequently, through the selective use and dissemination of information, decision makers attempt to manipulate public opinion and the decision making of Ministers. Majone (1989) recognises alternative tools of environmental regulation will critically affect the position and power of policy actors in markedly different ways, by altering the relative importance of the

resources they command. Thus, within the policy process, policy makers themselves will favour certain options over others as these maintain or enhance their position within the institution.

The structure and administrative procedures of the institution also play a critical role (O’Riordan 1976). The flow of information within institutions is often distorted by the organisational structure, as the division of responsibilities and roles across a number of separate departments, inhibits the development of an integrated approach and the preparation of comprehensive policy reviews. The established rules and procedures of day to day management, as well as the legacy of the past system of regulation, may also prove problematic promoting routine, standardised responses which create tension and conflict when confronted by new environmental problems, or new environmental pressure groups (O’Riordan 1976). As Weale (1992) recognises the natural response of policy makers to new environmental problems is to adapt existing legislation or policy procedures to save time and money. Nevertheless, this approach prevents a full scale analysis of the problem and the range of alternative policy responses. In fact by relying on past procedures, policy makers may perpetuate the displacement of problems to other media, times or places by replicating the mistakes of the past.

Analysis of the political, institutional and organisational context within which environmental policy develops is critical, providing key insight into the conflicts and contradictions which emerge over the form and function of environment-economy integration. These various political science perspectives provide key insights into the dynamic processes which together influence and shape the form and function of state intervention at the agriculture-water interface. The organisational, institutional and political constraints within which the regulators of water and agriculture operate could, in combination, perpetuate the displacement of environmental problems to other media, times or places. These various analyses have developed in a piece-meal fashion focusing on discrete portions of the policy process, the role of interest groups for example or the organisational structure of environment agencies, and failed to establish the connections between these various

elements in an integrated analysis of all stages of the environmental policy process. This gap is addressed in the state failure thesis.

In contrast to the market and bureaucratic failure theories put forward by welfare economists and public choice analysts, a number of political theorists (Dryzek 1987; Janicke 1990; Weale 1992; Andersen 1994) have developed a radically different theory to explain the failure of integration between the environment and economy. Drawing on the bureaucratic failure theory of the public choice school, this group of analysts radically rework the central tenets of this approach to develop an over-arching theory of state failure. This theory is based on the premise that state intervention itself is not a problem, rather inappropriate state intervention creates difficulties which compound rather than alleviate problems. The approach recognises that the failure of state intervention is not simply the result of bureaucratic behaviour or inefficient administrative regulations, but instead the result of unfavourable interaction between market and state institutions (Andersen 1994).

Environmental policy reflects the failure of State intervention with a number of problems the direct result of inappropriate Government intervention (Andersen 1994). The state failure thesis recognises that Government action, or more appropriately inaction, is a significant force generating many of the world's environmental problems. By failing to adopt a preventative approach to pollution control, and environmental policy in general, the state perpetuates an incremental process of policy reform which only succeeds in shifting the problems from one media, time or place to another. Nevertheless, breaking this mode of policy making is no easy task as a powerful set of vested interests have built up around the environmental policy domain. The progressive increase in the budget of state environmental agencies has contributed to the evolution of an eco-industrial complex (Andersen 1994). State agencies continually search for technical solutions which do not question the existing pattern of production and consumption; while industries concentrate on producing standardised end-of-pipe technologies which are available *en masse*. This process,

according to Janicke (1990) produces technocratic iatrogenesis³, whereby as more money is spent by the state on end-of-pipe technologies, less attention is directed to preventative approaches. Industry follows this lead, and as subsidies are paid to encourage up take of end-of-pipe technologies, industry itself directs less attention to innovations within the production process which prevent pollution and environmental damage. This failure to instigate preventative action is deeply ingrained, and according to Janicke (1990) is a structuring problem of policy rather than a failure to produce environmental goods and services. The origins of this failure lie in the original construction and definition of environmental 'problems' by policy makers as alternative theories are put forward to explain a problem, which in turn critically shape and determine the policy approach (Weale 1992).

The state failure thesis provides critical insight into the key processes shaping state intervention at the agriculture-water interface. In particular, the emphasis on how inappropriate Government intervention in fact perpetuates the dynamic displacement of environmental problems, marks an important contribution, revealing how state intervention created many environmental problems in the water sector. It also reveals the importance of vested interests in shaping the inter-relationship between civil servants and the water industry, which potentially prevents an alternative pro-active approach to the protection of the water environment. Despite these important contributions, the various political science perspectives provide only a partial insight into the dynamic processes at work by providing only limited insight into the decision making behaviour of the regulated. Focusing solely on the decision making of state institutions and their interaction with interest groups, provides only a limited understanding of the diverse ways in which the regulated behave towards, and in, the environment.

³ This is the phenomenon whereby a disease is induced by a doctor.

2.2.4: Behaviourist approaches to the environment.

The political science perspective on environmental/resource conflicts clearly identifies the political and institutional constraints within which policy makers operate. This emphasis on the actual behaviour of policy makers and interest groups enables recognition of the processes which together influence and distort the design, implementation and assessment of environmental policy.

Nevertheless, this perspective provides only limited insight into the behaviour of the regulated, as targets of specific environmental policy tools. The failure of the regulated to behave in the 'rational' manner prescribed in economic theory is demonstrated in a number of empirical studies (Rees 1992; Jackson and Jacobs 1991; Jacobs 1994; Rees and Williams 1993). Lack of information, constraints of time, capital restrictions and the organisational structure of the company contribute to the failure of firms and individuals to respond to economic incentives in the prescribed manner. The perception, knowledge and understanding of the environmental policy signal is critical in influencing the response of the individual or firm, and brings to the forefront of analysis the process of individual decision making. These processes are largely ignored in both economic and political science approaches to the environment, or are subsumed within the black box of "decision making" which fail to explicitly identify the combination of processes which together influence and shape the response of the regulated to specific environmental policies.

Decision making processes have been the central focus of a number of approaches in geography and sociology where analysts have attempted to shift attention away from *Homo economicus* to *Homo sociologus*. However, these approaches have been subject to intensive criticism, primarily from Marxist and neo-marxist analysts for ignoring the relations of power and dependence within which individuals are located (Watts 1983). Although it is accepted that these processes critically undermine or constrain the behaviour of the individual, this gap does not devalue completely the contribution of behaviourist approaches to understanding the response of individuals and firms to alternative environmental policies.

Within geography, there has been a long tradition of analysis focusing on the perception, attitudes and values motivating the behaviour of individuals and firms in relation to natural hazards (Burton *et al* 1978; White 1945, 1974, 1954; Kates 1985, 1962). The central thesis of the classic work of Burton *et al* (1978) argues that human response to hazards is in fact related to people's perception of the phenomena and their knowledge of alternative adjustment options. A 'tree' of alternative responses is possible, involving short and long run adjustments by individuals, groups or institutions, which in turn, alter their capacity to absorb the effects of extreme environmental fluctuations. The choice of adjustment pathway is purely subjective and will depend on the degree of risk individuals, groups and institutions are willing to bear which Burton *et al* (1978), drawing on Simon (1957), describe in terms of bounded rationality or satisficing behaviour. There are inter-personal and inter-collective differences in the perception of hazards, knowledge of adjustments and methods of evaluating decision criteria. Four factors are identified by Burton *et al* (1978) which critically influence the choice of adjustments. Firstly, prior experience of the hazard, in terms of the level of severity of the risk and the length of exposure to its consequences, critically influence and colour the perception and understanding of the hazard and in turn influence the type and number of adjustments made. Secondly, the wealth of the individual will influence the degree to which they willingly take risks, and in consequence the type of adjustment pattern they adopt. The third factor influencing the adjustment choice are personality traits, especially in response to severe, intensive events. Finally, the social role of the individual in a group or institution is also identified as influential.

Burton *et al*'s (1978) analysis has been highly influential in both academic and policy discourse and has been applied to a wide range of empirical phenomena. Nevertheless, the approach has been subject to intensive criticism on three levels. Firstly, the approach is criticised on the grounds of its positivist orientation, primarily reflected in its failure to address the political-economic and institutional processes which directly and indirectly impinge on and distort individual decision making (Watts 1983). Individual and collective decision making is not simply an either/or choice

between competing alternatives. There is a whole series of dynamic forces of change which directly and indirectly influence the decision making process. These processes both constrain and enable particular courses of action and are critical in directing individuals along particular pathways. The second point of criticism focuses on the exclusive analysis of extreme geophysical events such as drought or tornadoes which detract attention away from everyday or common place events which pose just as many risks and uncertainties for individual and collective decision making (Emel and Peet 1989). Failure to address the combination of extreme and everyday occurrences in analysis, leads to a very limited understanding of the dynamic processes of change which together alter the perception, knowledge and evaluation of the relative risks and uncertainties posed by a particular event or course of events. As the literatures from sociology and psychology reveal, risks are not merely linked to hazardous events (Beck 1992; Renn 1992; Royal Society 1992; Gerrard 1995; Lash and Wynn 1992). The final point of criticism focuses on the failure of the behaviourist approach to examine the source of individual and collective values and beliefs which affect behaviour in or on the environment, and the processes through which belief systems are maintained (Emel and Peet 1989). Failure to address the wider set of social values which influence the perception and evaluation of hazardous events leads to a very limited understanding of the processes at work.

A number of factors shape the response of the regulated to specific environmental policy signals, not least the morass of other direct and indirect state, market and social forces of regulation which are pushing and pulling the regulated in different directions. Nevertheless, the literature on environmental hazards offers very limited insight into the complex trade offs calculated in decision making, and it is therefore vital to draw on a number of theoretical and conceptual themes from other fields of analysis, primarily the literature on the theory of the firm and decision making under conditions of risk and uncertainty, which although not directly focused on the environment could potentially prove useful.

The literature on decision making under risk and uncertainty provides a number of key insights into the processes which together influence and distort the assessment and formulation of management strategies by individuals and firms. The literature on risk has firmly moved away from the conceptualisation of risk and risk perception as a simple mathematical measure. The emphasis is now placed on risk as an inherently multi-dimensional process (Royal Society 1992) encompassing social, political, economic, physical and institutional dimensions which mean different things to different people in different contexts. Thus, a specific environmental policy signal will pose social, financial, political, environmental and institutional risks and uncertainties for the regulated. The formulation of management strategies in response to a particular risk is not simply based on the individual's perception and assessment of the relative costs and benefits of alternative courses of action. Complex factors such as the individual's knowledge and experience of particular risk dimensions will critically influence the response (Dasgupta 1982). In addition, the response to a particular risk will be conditioned or constrained by management strategies developed in response to other direct and indirect forces of regulation, which themselves pose distinctly different risks and uncertainties. Thus individuals and firms are involved in a complex decision making process, calculating trade-offs between competing risk dimensions in order to formulate a coherent management strategy.

A largely unacknowledged dynamic underlying risk management strategies, is the process of risk reallocation (Arrow 1971; Beck 1992) which is defined by Balch and Wu (1974) as

“By way of reducing uncertainties that attend to their own environments, risk averse actors often succeed in shifting the risk for others to bear” (p20)

The most obvious and simplest example of risk reallocation is the operation of insurance markets, where individuals and firms purchase insurance against a range of uncertain future events such as fire, death and accidents. It is deemed inefficient for individuals to allocate their own capital resources to protect against uncertain future events. Thus they shift the cost of future events by payment of a small amount of money now, payable contingent upon the occurrence of certain

defined events (Arrow 1971). Government intervention also seeks to reallocate risk through direct regulations establishing liability for risk events, or through indirect regulatory mechanisms such as information campaigns (Segerson 1992).

Mechanisms operating at the individual firm level also attempt to reallocate the risks associated with production in order to avoid uncertainty and exert control over their production environment (Cyert and March 1963; Crew 1975; Galbraith 1967). The principal means of achieving this is through forward contracts or vertical integration (Balch and Wu 1974) where economic and production risk is reallocated either backwards onto input suppliers or forwards onto product output users. Thus, forward contracts reduce the level of economic risk and uncertainty associated with production as the firm is guaranteed a market and hence payment for goods. The purchasing firm also reduces production and economic risk as they are guaranteed a specific, quality product at a specific price without incurring any of the financial risks associated with production such as machinery break down or employee problems. Firms also exert control over uncertainty through inventory, employment and price policies which aim to influence, channel or redefine the behaviour of those who populate their market in order to ensure the optimal organisation of production (Balch and Wu 1974). Reorganisation of the structure of the firm through scale enlargement and diversification also aims to internalise the intrinsic production and market uncertainties. Risk pooling, risk spreading and risk insurance strategies play a key role for firms operating under conditions of uncertainty (Arrow 1971; Balch and Wu 1974; Segerson 1992).

This literature focuses, unsurprisingly, on the economic dimension of risk, where strategies are assumed to mitigate the financial impact of risk over both the long and short term in line with the utility maximisation thesis. This perspective ignores the fact however, that social, political and environmental risks are also reallocated within this process for others in society to bear now, and in the future. Analysis of risk and uncertainty and the implications for decision making processes provide key insights into the complex trade-offs calculated between alternative management

strategies, which potentially influence behaviour towards and in the environment. The fact that individuals and firms attempt to shift the risks of production and consumption for others to bear, potentially enlightens analysis of the process of problem displacement, linking the dynamic processes influencing decision making strategies to clear environmental outcomes.

The theory of the firm also provides key insights into the decision making processes of firms and individuals, particularly its critique of the profit maximisation postulate of neo-classical economics and is useful to analysis of environmental-resource conflicts. The neo-classical model of perfect competition and monopoly implies decisions are taken by individuals or entrepreneurs whose sole objective is profit maximisation. Nevertheless, a considerable body of evidence now questions the assumptions of this model, in particular the notion of rationality and the contention that a firm's main objective is the maximisation of profits over the short and long term (Scitovsky 1943; Lesler 1949; Nettle 1957; McGuire 1964). The separation of ownership from managerial control in most modern firms, creates a situation whereby the key decisions are taken by employed managers whose perspective and objectives are markedly different to those of the shareholders (Berle and Means 1932; Marris 1964; Galbraith 1974). Thus, profit maximisation may not be the sole criterion influencing decision making, with a number of other goals and objectives such as power, control, prestige and the desire for a 'quiet life' influencing the manager's decision (Papandreon 1952; Williamson 1964). In small firms the overriding objectives are the maintenance of autonomy, independence and survival above financial profit (Boswell 1973; Stanworth and Curran 1973; Storey 1982). While not denying profits are important, analysts suggest that utility maximisation will include a number of key criteria including personal as well as business objectives. This conforms to the principle of bounded rationality where individuals are conceived as 'satisficing' rather than optimising (Simon 1957), and develop strategies which are in line with the individual's own scale of values, perceptions and subjective view of the situation.

The second key line of criticism in the literature on the theory of the firm focuses on the role of the entrepreneur, which was largely disregarded in early economic theory (Baumol 1968). The lack of rigorous theoretical conceptualisation regarding the role and significance of the entrepreneur reflects the problems encountered defining what an entrepreneur actually is. Schumpeter (1934) emphasises the role as an innovator who starts new firms, while Marshall (1961) emphasises the entrepreneur's risk taking rather than innovating behaviour. Casson (1982) builds on this work and argues entrepreneurs behave differently because they have different perceptions of the situation which arise from unequal access to information or variable interpretations of it. Access to and use of information is a critical input into the decision making process. Nevertheless, the separation of decision making responsibilities into discrete units ensures managers do not always have full information, as the relevant facts are dispersed across a number of different departments, thus preventing the optimal or most rational response. The internal organisation of the firm, and the division of responsibilities among managers critically influence the firm's response to alternative policy signals, and is revealed in a number of empirical analyses (Rees et al 1993; Pearson and Smith 1990; Jacobs 1994). The conception of the firm as a collection of sectional interests with competing aims and objectives, and unequal access to power and information, provides key insight into understanding the nature of inter-firm relationships which in turn shape the form and function of market forces of regulation.

Understanding the complex and dynamic decision making processes which shape the behaviour of individuals and firms towards and in the environment must draw on a multiplicity of perspectives to address the range of processes which are occurring simultaneously. Response cannot simply be reduced to an either/or choice between alternative strategies, but is often influenced by a range of factors. These include not only the individuals subjective values, perceptions and experience of the environment emphasised by the literature on hazards but also the evaluation by individuals and firms of the relative risks and uncertainties posed by particular courses of action, which are addressed in the literature on risk and uncertainty. The theory of the firm also provides key insights,

emphasising how access to information and the internal organisation of the company can potentially distort the response of individuals and firms to environmental policies. These various strands of analysis provide a key insight into the complex and dynamic decision making processes of firms and individuals and could potentially enlighten analysis of not only the decision making processes of farmers, but also understanding of the market forces of regulation. These literatures in combination highlight the complex and dynamic processes which influence decision making at the local, regional and national levels.

2.2.5: The political economy approach to the environment.

The Marxist schools in both geography and sociology remained largely silent on the question of nature throughout the 1960s and 1970s (Fitzsimmons 1989), and only in the 1980s did the radical left start to seriously examine the nature - society relationship, with Smith (1984) developing the production of nature thesis.

The conceptualisation has been highly influential, particularly in its application to the analysis of social and physical space where it addresses the process of spatial restructuring in rural and urban areas in both industrialised and “third” world countries (Marsden *et al* 1987; Watts 1989). This however, has diverted attention away from the production of nature thesis, which has received limited theoretical analysis in the literature (but see Roberts and Emel (1992) for one of the first applications of the thesis to contemporary environmental conflicts) and left unchallenged some of the basic assumptions of the thesis. In fact, the production of nature thesis provides only a partial representation of the complexity which characterises environmental conflicts and there is a danger that this perspective overemphasises the social dimension, creating a highly socialised nature, where environmental problems are only produced through human intervention. This is not the case, as the environment is not simply reducible to the social relations of production (Benton 1994; Whatmore and Boucher 1993); environmental systems themselves represent highly dynamic and complex processes which have evolved across time and space. In fact, the environment represents the

ultimate structural constraint on human development as resources are not only physically finite, but also the ability of ecosystems to absorb waste products is limited. Recognition of this material dimension has been neglected in Marxist analyses of the nature-society relationship, and so consequently a static conceptualisation predominates, where society “does things” to nature (Dickens 1992), and the interaction and interdependence between these two highly dynamic and complex economic and environmental systems is neglected.

The Marxist and neo-marxist conceptualisations of the nature-society relationship offer only a limited understanding of the complex and dynamic inter-relationships which characterise the agriculture-water interface. The emphasis on the structural dynamic of the capitalist system of production implies environmental problems are an inevitable consequence of commodity production. In consequence, this perspective focuses analysis on the social, political and economic processes of production and consumption which together produce environmental problems. Through highlighting the relations of power and dependence which underpin interaction between the state and individuals, firms and individuals, and individuals themselves, this framework traces the dynamic social relations which shape and influence behaviour towards the environment. Despite this important contribution however, the approach ignores the dynamic ecological processes which interact with, and influence, social systems and vice versa.

This approach provides only limited understanding of the behaviour of the regulated, who are not passive recipients of change, but are actively involved in, and shape, their own behaviour towards the environment. The political economy approach provides little insight into the complex decision making processes of individuals, firms and Governments, as it focuses solely on the processes of interaction between these different actors, rather than the internal relationships which critically colour and shape their response to specific environmental policy initiatives. These are critical failings which are partially addressed in the political ecology framework of analysis.

2.2.6: The political ecology approach to the environment.

The political ecology framework of analysis, emerging in geography and sociology, draws on the neo-marxist approach and attempts to

“..combine the concerns of ecology with a broadly defined political economy. Together this encompasses the constantly shifting dialectic between society and land based resources, and also within classes and groups within society itself” (Blaikie and Brookfield 1987. p17).

The approach focuses on the diverse interplay between dynamic social, political, economic and institutional processes and the relationship of these forces to environmental change at the local level. The point of entry into understanding the complex and dynamic processes of socio-economic and ecological change is the resource manager at the local level. This so called “bottom up” approach (Blaikie and Brookfield 1987) focuses on the opportunities and constraints operating at the household level and how these influence the perception, valuation and use of resources. The approach then traces the economic, political, social and institutional constraints operating at the local, regional, national and even international level which impinge on and distort household resource decision making.

To date, the most sophisticated applications of this approach have focused on Third World environmental problems, with Blaikie and Brookfield (1987) applying this framework to land degradation problems in Africa and Nepal. They argue the legacy of the distinctive social, economic, political and institutional changes instigated in the colonial period have major impacts on the way in which resource managers at the local level value and use their resources today. Only reform and change in these spheres in conjunction with soil conservation programmes will alleviate the problems of land degradation.

The political ecology framework is also critically influencing the research agenda of those working on the environment in advanced agricultures (see for example Clark and Lowe 1992; Ward and Munton 1992; Whatmore and Boucher 1993). In particular Ward (1994a,b) successfully locates the

dynamic of agricultural pesticide pollution in the intersection between the up-stream food system fuelling farm level adoption of pesticides, and the changing emphasis of the scientific and policy communities on environmental pollution in the countryside. This analysis does not conceive of pesticide pollution as a purely environmental problem, but as a by-product of the socially constructed technological treadmill. In consequence, pesticide pollution is conceptualised as the outcome of specific social, political, economic, institutional and ecological processes which together contribute to the framing of pesticide use as a problem, which is clearly contested amongst competing interests, who attempt to influence the direction and pace of regulatory change.

Despite providing an holistic framework for analysis of environmental conflicts, Bryant (1992) warns those working on the political ecology approach, particularly in “Third World” countries, against falling into the trap of economic reductionism. In fact he identifies three key areas where economic reductionism creeps into analysis. Firstly, reductionism fails to attribute sufficient explanatory significance to ecological processes. Neglecting the highly dynamic processes of ecological change creates a highly socialised nature, where ecological processes are marginalised in the analysis. Secondly, important sources of environmental change are neglected by ignoring the role and significance of state and inter-state interaction. These processes are critical to understanding the often differentiated and contradictory ways in which responses to environmental change develop. Finally, and perhaps most importantly, Bryant argues that the political ecology approach often neglects the central question of power from analysis. The role of those “without” power and the most socially disadvantaged is critical to understanding the causes and consequences of environmental change. The political ecology approach replicates the mistakes of the Marxist and neo-marxist perspectives on the environment; as Benton (1994) argues, the relationship between nature and society cannot simply be reduced to the social relations of production. Dynamic ecological processes of interaction and interdependence cannot be excluded to the margins of analysis. This is reflected in the work of Ward (1994b) and Clarke and Lowe (1992) who emphasise

the dynamic social processes of change framing environmental pollution problems, but ignore or sideline the critical ecological processes which also play a significant role.

The criticisms of Emel and Peet (1989) also have specific relevance to the analysis of the agriculture-water interface as they identify the importance of the poorly developed conceptualisation of resource decision making processes in the political ecology approach. The 'black box' approach to decision making fails to open up the complex and contradictory trade-offs which are calculated by farmers at the local level. Responses do not simply materialise out of nowhere, but reflect a combination of influences, perceptions and experiences which critically shape the development of management strategies. While Blaikie and Brookfield (1989) emphasise the importance of examining the way in which state, market and social forces of regulation influence decision making, they fail to examine the complex trade-offs which are calculated between these competing signals and the implications for behaviour towards, and in, the environment. The development of management strategies is influenced by individual perception, past experience, access to information on alternative options and evaluation of the relative risks and uncertainties posed by particular courses of action. These decision making processes are critical but are, nevertheless ignored in the political ecology approach, which fails to address the complex and dynamic internal and external relations of production and consumption which in combination influence decision making at the local level.

The political ecology framework of analysis potentially provides significant insights into the dynamic processes at work at the agriculture-water interface. The assertion by Blaikie and Brookfield (1987) that the framework ties ecology to a broadly defined political economy, linking local level resource decision making to the regional, national and international forces of regulation, offers a way of breaking down and assessing the combination of forces which together shape and distort the management and use of irrigation water. Nevertheless, there are a number of critical gaps which undermine its theoretical coherence and ability to reveal and understand the complex and

dynamic processes at work. Most significantly the political ecology framework provides little insight into the actual decision making processes of farmers. It is central to the analysis to explicitly identify the way in which farmers' knowledge, perception and assessment of the water environment influence their use and management of irrigation water. How are these processes shaped and distorted by management strategies developed in response to the other direct and indirect state, market and social forces of regulation? The failure of the political ecology approach to directly address the decision making of actors within state institutions is also of critical importance to this analysis. The state is not a benign or neutral force; competing interests within the state critically shape and distort the environmental policy process. Policy makers within the agricultural and water sectors have distinctly different interests in, and perceptions of, environmental regulation which is potentially translated into conflict over the form and function of state intervention. These conflicts and contradictions lie at the centre of the agriculture-water interface and the political ecology framework provides only partial insight into these dynamic processes.

2.3 The way forward: a theoretical framework of analysis for the agriculture-water interface.

These alternative conceptualisations of the nature-society relationship emphasise competing market and state failure theories in explaining contemporary environmental - resource conflicts. The brief review of the key parameters of these various approaches highlights their relevance and applicability in understanding the complex and dynamic inter-relationships which characterise the agriculture-water interface. Apart from the state failure thesis developed by Janicke (1990), none of the other political, economic or social approaches directly addresses the dynamic displacement of environmental problems from one media, time or place to another. The dynamism which is inherent in both ecological and social systems is only alluded to, and rarely incorporated directly into analysis.

The simplification of the environment-society relationship prevents clear identification and analysis of the complex and contradictory processes which together contribute to contemporary environmental/resource conflicts. Political scientists, economists, sociologists and geographers focus on the environment-society relationship from the confines of their own discipline and, in consequence, direct attention solely on the political bargaining processes, institutional decision making, the definition and allocation of property rights to the environment, and estimates of the appropriate or most efficient level of environmental protection. While not denying the importance or significance of these processes, on their own they provide only partial insight into the complex and dynamic processes which shape and distort the agriculture-water interface. Consequently, in conceptualising the agriculture-water interface there is no over-arching theoretical framework which explicitly addresses the central dimensions of the nature-society relationship identified in section 2.1. No one approach can be used exclusively to understand the processes at work (Rees 1990; Weale 1992) as the simple one dimensional analyses of the nature - society relationship provide only a partial insight into the complex and dynamic processes of interaction. Thus, there is a need for a new, alternative approach which avoids the confines of specific models, theories and disciplinary perspectives in order to reveal the complex processes which together underpin the nature-society relationship. This demands an inter-disciplinary perspective which draws on various theories from economics, politics, geography and sociology to reveal the complex, multi-dimensional processes at work.

The development of an inter-disciplinary framework of analysis however is no simple task, and there is a danger that it merely reverts to a sweeping, all embracing approach typified in the political ecology literature. This approach pre-determines at the outset that economic, political, institutional, administrative, social and environmental processes all contribute to the specific environmental-resource conflict under analysis. This presupposes that these processes are all involved and thus they are all accorded equal weight and significance in the analysis. However, as

Weale (1992) recognises, some theories or models will in fact prove more useful to the analysis of environmental problems than others, as he himself argues

“..we need to combine idioms, or at least recognise that not all parts of the story can be told in the same voice. Does this mean that it is entirely a matter of personal whim and predilection which idiom we choose to work with? Not so, I conjecture, for whereas some idioms may be essential when accounting for the context of policy, others may be essential in accounting for its logic. Or, to change the metaphor, one or two voices may give us the melody line, leaving only the accompaniment for other voices” (p214).

In light of these criticisms, this analysis develops an alternative approach which identifies six theoretical postulates, drawn from a number of disciplinary perspectives, which may potentially enlighten analysis of the agriculture-water interface. The specification of these multiple and conditional hypotheses ensures the transparency of the complex processes at work and addresses the five key levels of analysis identified at the end of section 2.2. A critical distinction is drawn between the relationships of interaction between farmers, off-farm firms, state agencies and farmer representative groups, and the internal relationships which critically shape not only farmers decision making but also the form and function of state, market and social forces of regulation. These complex inter-relationships are represented in figure 2.1, which pinpoints the dynamic processes of interaction not only between farmers and state, market and social forces of regulation, but also the key points of inter-linkage between these different forces of regulation themselves.

The six postulates encompass the theory of state failure; the political economy tradition with its emphasis on the relations of power and dependence; the process of risk reallocation; the theory of the firm; the role of risk and uncertainty on decision making; and finally the institutional and administrative constraints of environmental policy makers. In order to reveal the explanatory value and significance of these various models and theories, it is vital to specify more precisely, through multiple hypotheses, the complex processes of interaction they attempt to expose.

- The state failure thesis argues that inappropriate state intervention in fact perpetuates and prolongs many of the world's environmental problems (Janicke 1990; Andersen 1994). This framework will be drawn on to explore the contention that inappropriate Government intervention in fact creates many of the environmental problems in the UK water sector, preventing movement towards an integrated environmental policy. This framework focuses on the inter-relations between policy makers and external interests, and will be drawn on to explore the relative power and influence of different state and social forces of regulation in shaping the integration of the environment into water and agricultural policy.
- The state failure thesis addresses the dynamic inter-relations between state and social forces of regulation. Nevertheless, it does not expose the institutional and administrative constraints which also play a significant role in shaping the form and function of state intervention (O'Riordan 1976 ; Weale *et al* 1991). The political science critique of environmental policy reveals how asymmetrical bargaining power, constraints over access to information within the institution, standardised rules and procedures and the past system of regulation are critical processes and could play a major role shaping the form and function of state intervention at the agriculture-water interface.
- The theory of the firm focuses on the dynamic internal relationships which critically shape and influence decision making, and is relevant to understanding the behaviour of farmers and off-farm firms. The internal organisational factors which shape behaviour of firms, such as the division of responsibilities between managers, constraints of capital and time and lack of information could prove central to understanding the form and function of market forces of regulation.
- Understanding of the dynamic forces of market regulation is potentially enhanced by the literature on risk reallocation (Balch and Wu 1974). The contention that, as firms attempt to reduce the risks and uncertainties attendant on their own production environment, they

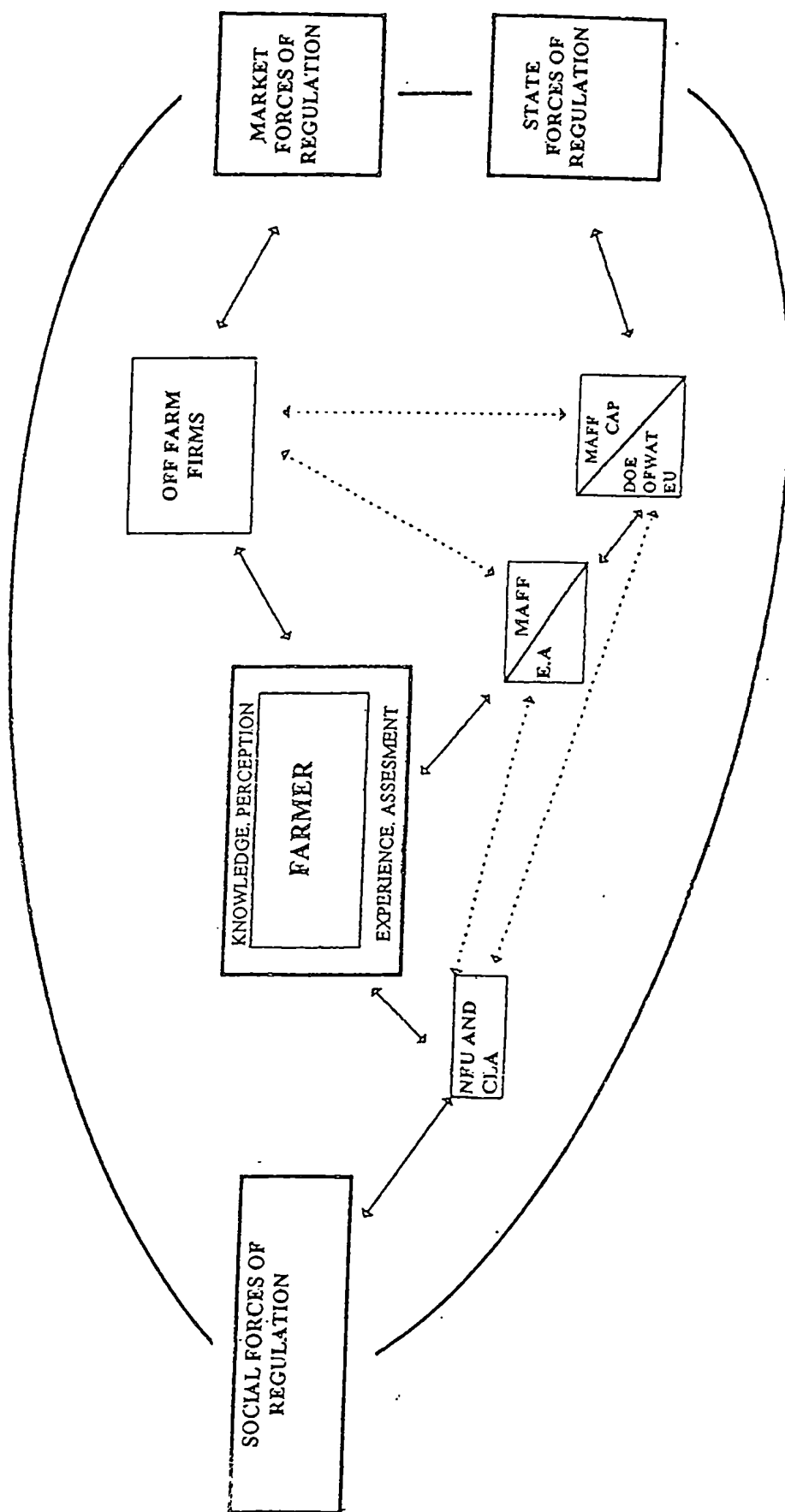


Figure 2.1: The central inter-relationships at the agriculture-water interface

also succeed in reallocating risks for others to bear, provides critical insights into the form and function of market forces of regulation. These risk averse strategies could critically shape inter-firm relationships among the off-farm firms, which in turn could critically shape the form and function of their inter-relationship with farmers at the local level.

- The plethora of state, market and social forces of regulation relay conflicting signals to farmers and it is vital to expose the complex trade-offs they calculate in order to understand their response, or more importantly non-response, to specific environmental policy signals. The decision making processes of farmers are critical, and it is clear from the literature on the theory of the firm, natural hazards and decision making under conditions of risk and uncertainty, that a number of factors could play a central role. Access to information, past experience and knowledge, all critically shape the perception and evaluation of alternative management options. Other management objectives, constraints of capital and labour could also play a vital role shaping their response. It is vital to move away from the conception of the individual as “rational economic person”, which predominates in economic analysis, and recognise the central role of social and cultural values in shaping behaviour.
- Finally, the political economy tradition with its emphasis on the relations of power and dependence could prove important in understanding the dynamic processes of interaction between state, market and social forces of regulation and the inter-relations which tie farmers with these forces of regulation at the agriculture-water interface, to reveal how they directly and indirectly control and manipulate decision making.

Drawing on these six theoretical postulates, the analysis will address the combination of processes which together shape and influence the agriculture-water interface. It will ensure the transparency of the key processes underpinning the dynamic displacement of environmental problems from one media, time or place to another and will thereby pinpoint the key factors distorting the integration of the environment and economy.

CHAPTER THREE

THE INTERFACE NETWORK METHODOLOGY AND EMPIRICAL STRATEGY

The conceptual approach outlined in Chapter Two opens up to analysis the complex and dynamic set of inter-relations and inter-dependencies which shape the agriculture-water interface. Recognition that no one model, theory or disciplinary perspective provides an over arching theoretical framework of analysis, shifts attention to the combination of economic, political, social, institutional and ecological processes which together shape and distort integration of the environment and economy. Central to this alternative approach is the identification of six theoretical postulates which address different dimensions of the agriculture-water interface problem. In light of this conceptual approach, it is vital to develop an empirical methodology which is capable of linking together and moving between these multiple layers, to provide a coherent and cohesive framework in which to ground the empirical analysis. The interface network concept is central to the development of this empirical strategy, as it is not merely a useful analytical device but also an important methodological approach.

This chapter will concentrate on the detailed elaboration of the interface-network methodology, with the objective of underlining its relevance and applicability to analysis of the agriculture-water interface. The chapter is divided into four sections, with the first section focusing on the key methodological issues confronted in the interface-network approach. Drawing on the work of Long (1989), Long and Long (1992) and Hawkins (1991), the analysis will outline the value of this actor orientated approach in exposing the network of social relations which directly and indirectly regulate the use and management of irrigation at the farm level, and the unintended environmental consequences and side effects which result. Having firmly established the broad methodological framework the analysis shifts attention to the detailed development of the empirical strategy. Consequently, the second section will focus on the choice of research area and will outline the central dimensions of the conflict catchment methodology. The chapter will then move on to consider the empirical strategy focusing on

the sample frame and research tools used in the field. The chapter will finally conclude with a brief examination of the methodological issues confronted in the analysis of the data.

3.1: The interface-network methodology.

Hitherto, use of the interface concept in this analysis has focused solely on its importance as an analytical device. Its application in Chapter One concentrated on highlighting the conflict of interests and values encountered at the inter-section between two distinctive, but inter-dependent economic and environmental systems. The concept revealed the complex and dynamic processes which underpin integration of the environment into both water and agricultural policy, and the unintended consequences and side effects which could potentially result. This section will build on this conceptualisation to develop the interface-network methodology, which provides a key mechanism for linking together the combination of processes which together shape and distort the agriculture-water interface.

The six theoretical postulates identified in Chapter Two address different dimensions of the agriculture-water interface problem, and reflect different methodological approaches incorporating both behaviouralist and structuralist traditions. Consequently, it is vital to develop a methodological approach which bridges the gap between these different perspectives, in order to ensure an integrated and cohesive empirical strategy. It is also critical to ensure the methodological approach moves between, and links together, the multiple layers of analysis to expose the complex and dynamic processes of interaction, and thereby prevent the ad hoc examination of discrete portions of the agriculture-water interface problem. The interface-network methodology, set out by Long (1989) and Long and Long (1992), fulfils these objectives, as it stresses the importance of understanding the dynamic and emergent nature of social change.

The divisions between wholly structuralist or wholly behaviouralist perspectives on social change are breaking down, as analysts recognise the central importance of examining the combination of structural

and behavioural forces which together contribute to the contradictory and conflicting outcomes of development (Long 1989; Giddens 1984). The interface-network approach provides a critical means of linking together these two traditions, by emphasising the dynamic interaction and inter-dependence between the internal and external relations of production and consumption. Recognising the inter-dependence between social agency and structure, the interface-network approach focuses on how social actors¹ interact with, and respond to, the political-economic environment to provide key insight into how structural forces shape and reshape their life worlds. As Long (1992) argues

“.. it is theoretically unsatisfactory to base one’s analysis on the concept of external determination. All forms of external intervention necessarily enter the existing life-worlds of the individuals and social groups affected, and in this way are mediated and transformed by these same actors and structures. Also to the extent that large scale and ‘remote’ social forces do alter the life chances and behaviour of individuals, they can only do so through shaping, directly and indirectly, the everyday life experiences and perceptions of the individuals concerned” (p21).

This alternative emphasis is critical to understanding the differential responses of actors to broadly similar structural conditions, and shifts analysis away from the conceptualisation of planned intervention as a linear, step by step process. Instead, it is exposed as an ongoing, socially constructed and negotiated process with unintended consequences and side effects.

Central to this actor orientated approach is the examination of the network of social relations within which individuals are embedded (Marsden and Murdoch 1990), to reveal how particular sets of relations condition particular courses of action. The conceptualisation of social agency plays a pivotal role in the interface-network approach, as it does not simply refer to the decision making capacity of actors or their intentions in doing things. Instead, social agency is linked to the concept of interests (Long 1992; Hindess 1986), which critically colour and shape the decision making process.

Consequently, analysis focuses on the strategies² which social actors develop in order to protect or

¹ Social actors have been characterised by Giddens (1984) as capable and knowledgeable beings, who process information, monitor events around them, note the reactions of others to their behaviour and take account of various contingent circumstances. Social actors include not only single individuals but also capitalist enterprises, state agencies, political parties and church organisations, as they are all capable of reaching and acting on decisions. Social agency should not however, be ascribed to collectivities, agglomerates or social categories such as class or gender which have no way of formulating or carrying out decisions themselves (Hindess 1986).

² The limitations associated with this concept are recognised, as debate has focused on what actually constitutes a strategy, and Crow (1989) has highlighted the dangers of imputing objectives to actors which they themselves may not recognise.

promote their particular social, political or economic interests from external intervention. In turn, this will expose the network of social relations through which social actors pursue their interests and interact with others to ensure their particular interests are served. This enables analysis to distinguish and draw out the discontinuities and conflicts of interest and values which emerge as a consequence of interaction, and the unintended side effects which result. Central to the analysis of these complex inter-relationships are the alternative frameworks of knowledge which the different actors draw on in pursuit of their interests, and the relations of power which enable certain 'ways of knowing' to take precedence (Giddens 1979; Long 1992; Marsden *et al* 1993). As Long (1992) suggests

“..if we take the view that we are dealing with ‘multiple realities’ potentially conflicting social and normative interests, and diverse and discontinuous configurations of knowledge then we must look closely at the issue of whose interpretations or models prevail over those of other actors and under what conditions. Knowledge processes are embedded in social processes that imply aspects of power, authority and legitimation, and they are just as likely to reflect and contribute to the conflict between groups as they are to lead to the establishment of common perceptions” (p26-27).

The key question therefore centres on how certain actors are able to impose their interests on others, and what linkages tie these different actors in a network of social relations.

Focusing on the processes of negotiation³ and representation⁴, or what Latour (1986; 1987) calls the process of translation, it is possible to resolve these questions by tracing how specific networks of social relations are established, extended and maintained. These complex processes of interaction are critical, as they expose the relations of power⁵ and dependence which underpin the enrolment of actors into networks. In order to effectively enrol actors into networks, two things must occur simultaneously; first others must be enrolled so that they participate in the network; second their

³ Negotiation attempts to open up and capture the process of mediation, or the manner in which actors interpret and internalise the advice they receive from other, external actors (Ward 1994b; Long 1989)

⁴ Representation refers to the ways in which actors seek to protect or promote their interests from external intervention. As Marsden *et al* (1993) recognise the process of representation is subject to continual struggle and renegotiation, as competing actors attempt to reshape the course of events around them to ensure that their specific interests are protected or promoted.

⁵ Power is not conceived as determined by the actors structural position in the class system, but as the outcome of collective action. Power is understood as a socially negotiated process whereby other actors are enrolled in a network of social relations where they work in unison towards a common goal (Latour 1986; 1987)

behaviour must be controlled so that their actions are predictable (Callon 1986). Consequently, if a strategically placed actor can convince others that a particular course of events will serve their interests, it is possible to build up and control a network of social relations. According to Callon (1986) four stages are discernible in this process. Firstly, an actor will make him/herself indispensable to others through the strategic control of resources such as information, access to skills or capital and then, through negotiations and representations, will convince others to join the network. Secondly, the strategically placed actor will attempt to remove the discretion from the world of other actors, by directly intervening in the alternative associations of these actors with others. In the third stage, the role and identity of each actor and the nature of their relationships with others is defined. Finally, the initiating actor “represents” the others, and speaks on their behalf in negotiations with the outside world. Thus power rests with those actors who are able to enrol and convince others to participate in their specific “project” and consequently build up a network of social relations. The initiating actor is able to closely regulate the network, through controlling the flow of information and capital and thereby succeeds in manipulating the pace and direction of change at the local level.

The utility of the interface-network approach is demonstrated in the work of Marsden and Arce (1995), Hawkins (1991) and Marsden *et al* (1993), who use this methodology to explore the interaction of farmers with off-farm firms and state agencies. Marsden and Arce (1995) in their analysis of agro-export agriculture in Chile, concentrate on the ways in which produce quality criteria are incorporated into the lifeworlds of agro-export firms. By focusing in particular on the role of the initiating actors, who in this case are multi-national companies, agricultural extension agencies and agricultural co-ops, the analysis reveals how strict produce quality criteria are introduced into a local area and to a group of individuals. This process critically influences and reshapes the relationship of the firm or co-op with its own employees, who act as the quality assessors when picking and packaging produce. The inter-relationship of these firms with other actors in the European market place are also redefined, as firms establish closer ties to guarantee quality and ensure against the possibility of produce rejection. The use of the interface-network approach in this particular case, enables analysis to trace how local level

agricultural production methods and employment practices are linked to national and international processes of change, as local firms are gradually incorporated into the “quality projects” of their overseas customers.

Hawkin’s (1991) study of technological change on potato and dairy farms in Cheshire uses the interface network approach to explore the divergent interests and strategies pursued by farmers and those who produce, sell or promote technology. Focusing in particular on the dissemination of new technologies from manufacturers to individual farmers, the analysis exposes the differential resources of knowledge and power drawn on by the different actors in the interface networks for milk and potatoes. The study underlines the different strategies of engagement developed by farmers as they negotiate the interface networks, to reveal how agribusinesses are never able to completely undermine the independent decision making capacity of farmers.

The application of the interface-network methodology provides a critical means of exposing the complex and dynamic web of inter-relationships which shape the use and management of irrigation water and the water environment. Chapter One argued that farmers enmeshed at the agriculture-water interface are the loci for a plethora of competing and conflicting signals, emanating from state, market and social forces of regulation which are pushing and pulling them in different directions. Recognition that the different actors from off the farm, as well as the farmers themselves, all have distinctly different interests in irrigation and the water environment, enables analysis to trace the conflict of interest and values which underpin the agriculture-water interface. Focusing on the alternative frameworks of knowledge, and the processes of negotiation and representation, it is possible to trace how the state, market and social forces of regulation control and manipulate not only each others’ behaviour, but also that of farmers. This will enable analysis to build up a picture of the network of social relations which directly and indirectly regulate irrigation use. The critical point of entry in opening up this web of inter-dependencies is the farmers at the local level. Only through tracking their interaction with different off-farm agencies, will it be possible to explore how these external agents

actually control and manipulate irrigation decision making. The degree to which farmers internalise these different “projects” into their own life worlds is critically important in understanding not only their irrigation management, but also their response or non response to demand management policies.

Farmers involvement with actors from the EA, MAFF, food system, NFU and CLA are primarily face to face encounters at the local level. Nevertheless, these different actors are themselves involved in complex inter-relationships with other actors from higher levels of their institution or firm. For example, EA officials at the local level, who are involved in the licensing and policing of irrigation abstraction, are enforcing regionally and nationally agreed policies on water abstraction and protection of the water environment. Thus they are the end point of a complex process of negotiation within the EA itself and also between the EA, OFWAT, DoE, MAFF and the Water Companies over the form and function of water policy. Firms involved in irrigated production, namely irrigation equipment manufacturers, irrigation advisers and the marketing outlets for irrigated produce, are themselves all part of the international food system through which firms directly and indirectly regulate each others behaviour. Consequently, it is vital to trace the key inter-relationships which critically shape the behaviour of these off-farm agencies, as this in turn critically shapes the form and function of their interaction with farmers. Focusing on the alternative frameworks of knowledge and resources which these different actors draw on, it is possible to track how they attempt to enrol and incorporate farmers into their own particular networks. The processes of negotiation and representation will expose the relations of power and dependence which enable these firms and organisations to directly and indirectly control and manipulate decision making at the farm level. The dynamic nature of these complex inter-relationships is critical, as farmers are progressively enrolled into the divergent “projects” of these off-farm firms and state agencies. How farmers reconcile the demands of these competing and contradictory projects and internalise them into their own management practices will prove critical in understanding their response or non response to demand management policies.

3.2 The conflict catchment methodology: choice of research areas

The interface network concept enables identification of the web of social relations within which farmers are embedded. Through tracking farmers' interaction with agents from off the farm, it is possible to explore the way in which state, market and social forces of regulation from the regional, national and international levels regulate the use and management of irrigation water and the unintended consequences and side effects which result. In applying this approach it is critical to locate these processes within particular places, to ensure the environmental dimension is closely integrated so that analysis can trace the dynamic displacement of environmental problems from one media, time or place to another. The forces influencing irrigation at the farm level may be national or international, but the outcomes are localised and reflected in the conflicts over access to, and use of, reliable supplies of irrigation water. The conflict catchment approach attempts to address these issues by explicitly identifying and linking the research areas to the central dimensions of the agriculture- water resource management conflict.

3.2.1: The national water supply and demand context in the UK.

It is impossible to divorce the allocation and regulation of water for use as spray irrigation from the wider context, as industry, the environment and public supply companies directly compete for available supplies of water. This is further complicated by the limited availability of new supply sources and uncertainty over the impact of climate change on both the supply and demand for water (Parry and Duncan 1995; Herrington 1996). Hence, it is vital to establish at the outset a clear picture of the national and regional supply and demand for water in the UK, as these competing pressures critically influence the choice of the research study area. In one sense, the availability of water in the UK is in fact not a problem, with high annual average rainfall levels an established feature of UK weather patterns. Despite this, not all the water which falls as rainfall actually finds its way into the rivers and aquifers, and a significant proportion is lost through evapotranspiration. Hence, the average annual effective rainfall figures represent the amount of water actually available to supply rivers and replenish

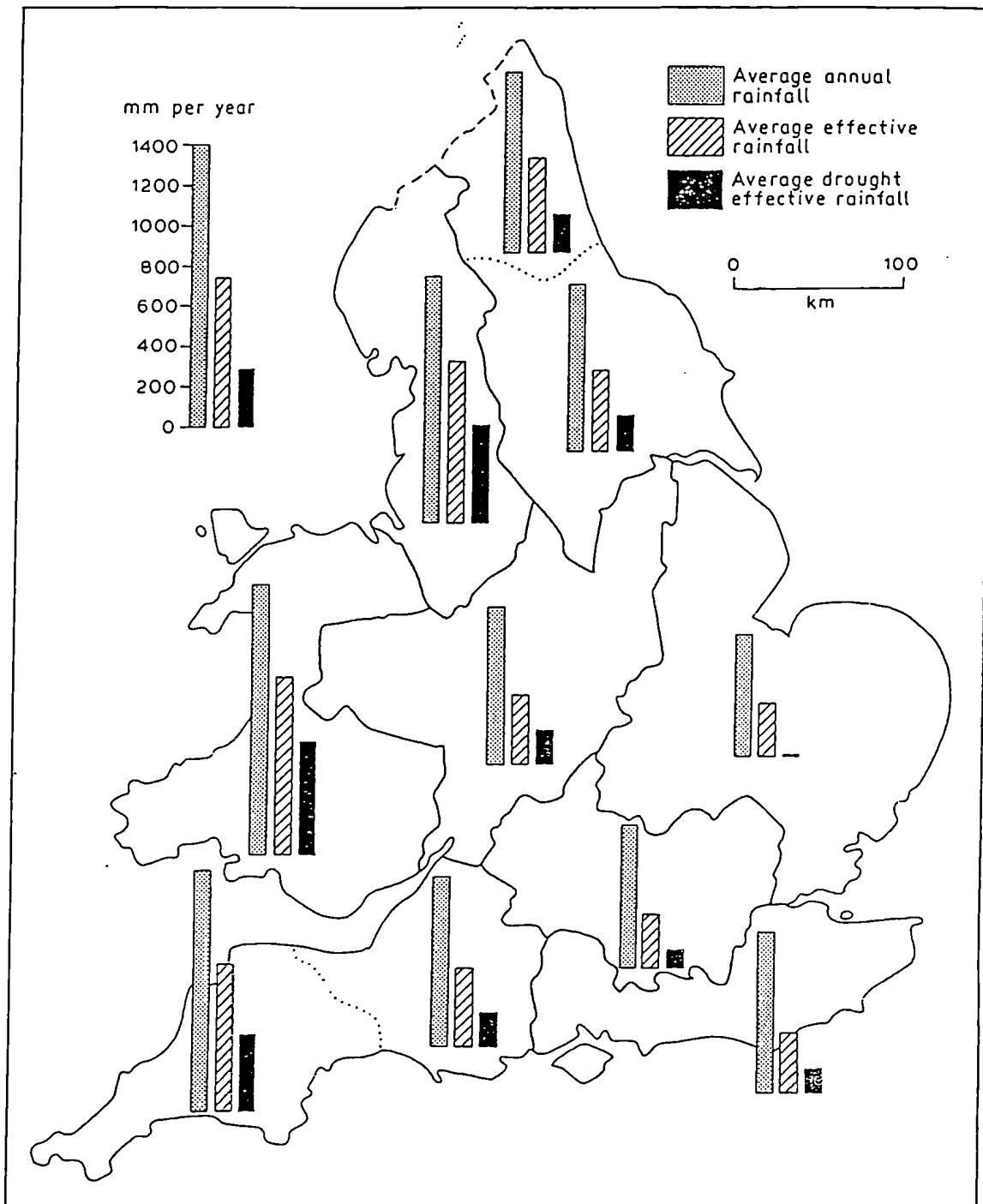


Figure 3.1: Average annual rainfall, effective rainfall and drought effective rainfall.

(Source: EA 1996)

aquifers. A significant proportion is lost through evapotranspiration, and less than 10% of this figure is authorised for abstraction by water companies, industry and agriculture. Nevertheless, this perception of plenty masks important regional differences, with a significant supply imbalance between the north and west of the UK, where annual average rainfall and effective rainfall levels are high, and the south and east which receive only a fraction of this figure (see figure 3.1). In fact, rainfall levels in the eastern and southern counties of England are on a par with rainfall levels in the south of France, and in the Anglian region the situation is particularly difficult with average annual rainfall figures of 595mm, of which 448mm are lost through evapotranspiration. This leaves 117mm for rivers and aquifers; 16mm for human use which is returned to source and 14mm used by humans but not returned to source (NRA 1993a). This picture is further complicated by the 1:50 year drought effective rainfall, which represents the average amount of rainfall available under conditions which might be expected to occur once every 50 years. Regional differences in average annual effective rainfall are sharply underlined in a drought situation, with the Anglian region suffering by far the lowest drought effective rainfall, followed by Thames, Southern and Severn Trent regions (see figure 3.1). In fact Anglian region is particularly vulnerable to relatively minor fluctuations in rainfall or evapotranspiration with summer rainfall levels of 300mm of which 450mm are lost through evapotranspiration. In effect every summer is a drought! (NRA 1993a).

These differences in effective and drought effective rainfall levels however have a variable impact, depending on the level of dependence on ground or surface water sources for abstraction supply. Southern, Thames, Anglian and Severn Trent regions overlie major aquifer outcrops which provide effective storage for water and in fact 30% of effective rainfall percolates through to these aquifers

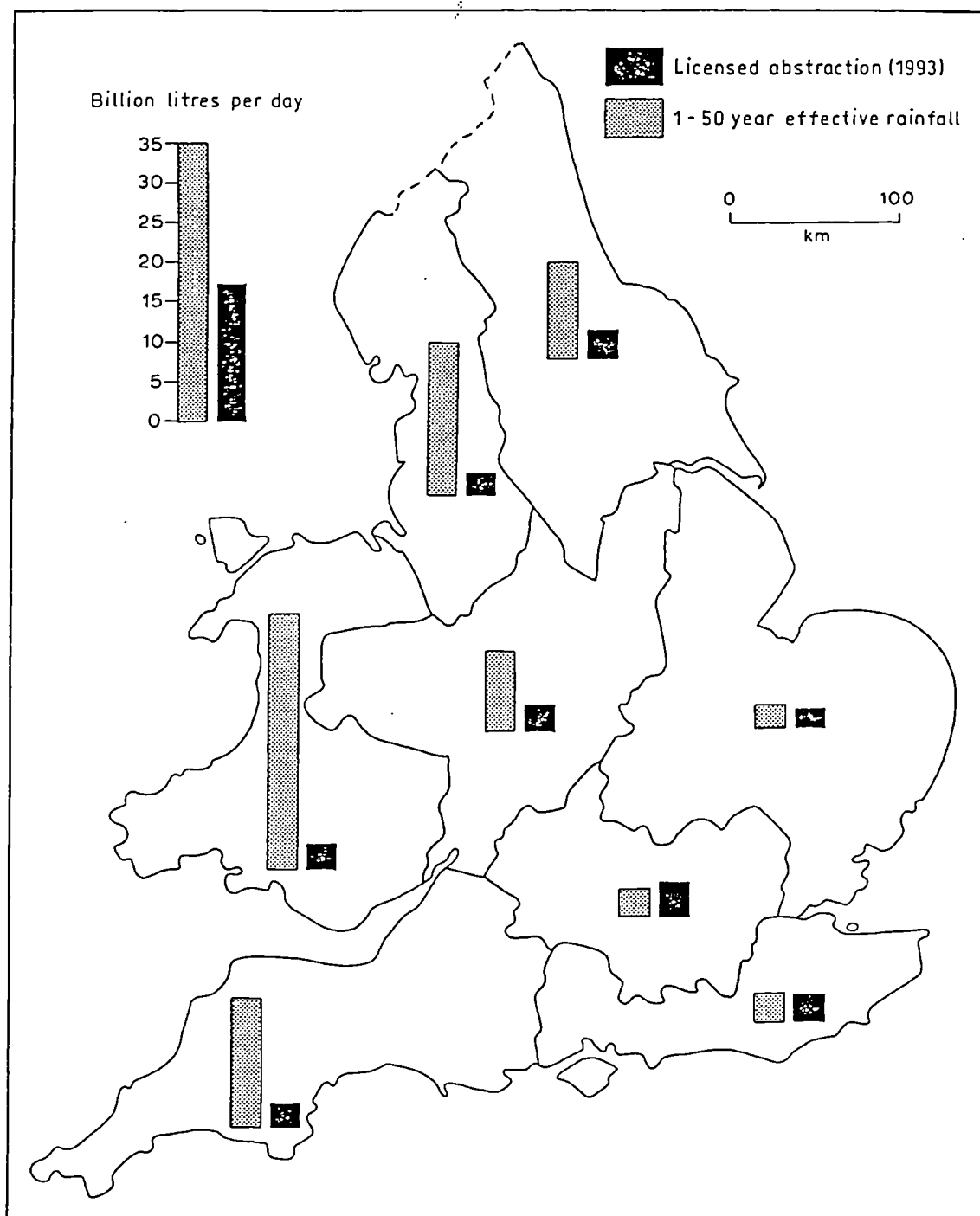


Figure 3.2: Effective rainfall and licensed abstraction.

(Source: EA 1996)

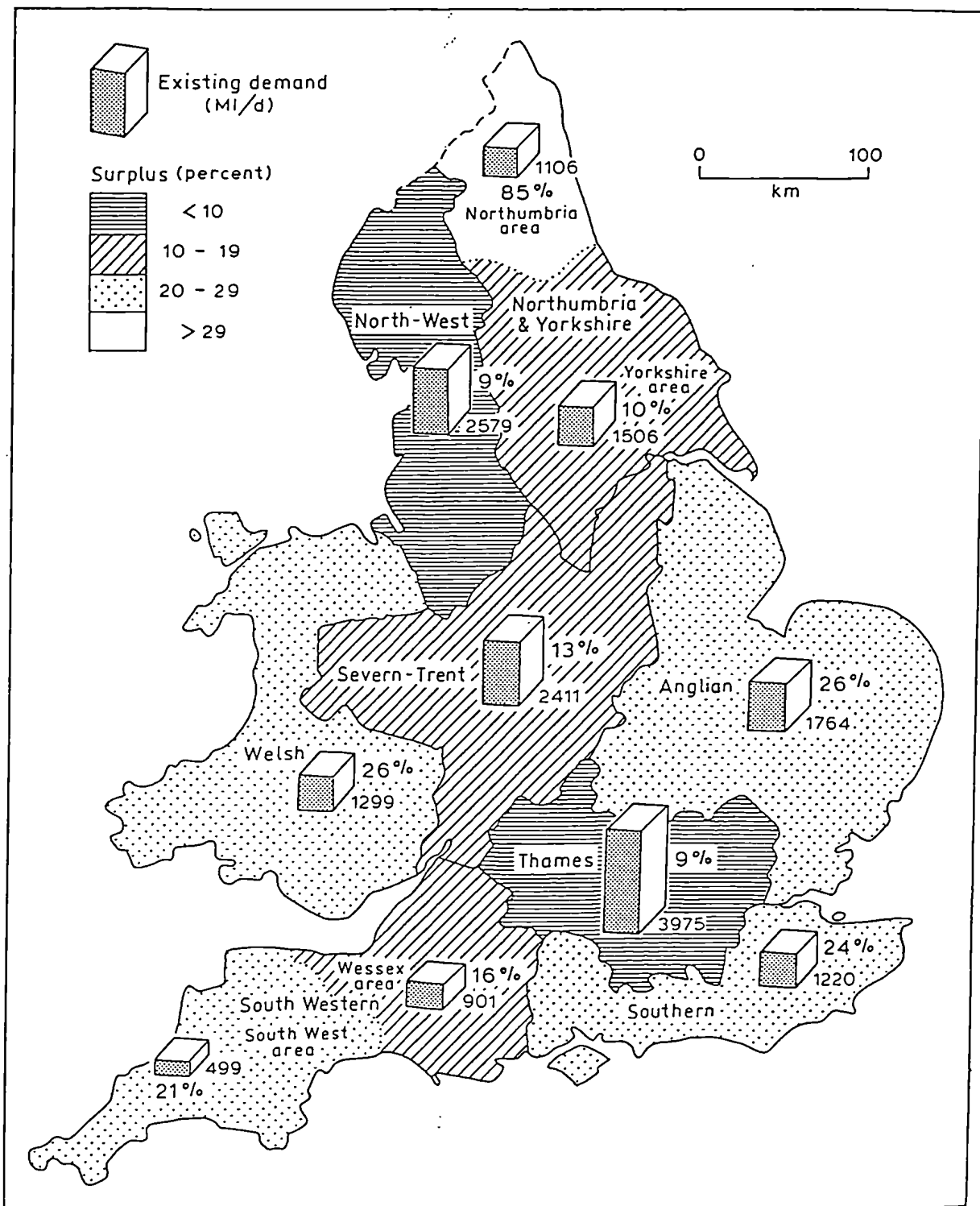


Figure 3.3: The present surplus (present regional average water supply surplus as a percentage of 1991 demand). (Source: NRA 1994b)

(NRA 1993a). In contrast, western and northern regions are dependent on surface waters and man made storage facilities, thus the impact of drought will be variable depending on the annual rainfall pattern. Notwithstanding the problems of low effective and drought effective rainfall, the south and east of England are also subject to very tight margins when comparing the 1:50 year drought effective rainfall against licensed abstraction (see figure 3.2). The regions with greatest resource stress also correspond with those regions with high, and increasing concentrations of population.

EA and water company calculations of the level of surplus resources suggest there are only limited 'new' supplies of water available for allocation. Water Company figures suggest surplus resources range from 85% in Northumbria, primarily as a result of under utilisation of Kielder reservoir, to 13% in Severn Trent and 26% in Anglian (see figure 3.3). These figures however may in fact under represent the seriousness of the situation, as they do not take account of the need to allocate water for the protection of the water environment. The availability of additional raw water for agricultural abstraction is also severely constrained. In Anglian region, summer abstraction from surface water is limited to those catchments where flows are augmented by the Ely-Ouse ground water scheme, the Ely-Ouse-Essex transfer scheme and the river Trent transfer as well as by returning effluents. Only winter abstraction, for storage, is permitted in all catchments. The availability of ground water is also limited with only a nominal surplus available in 8 catchments to meet minor local abstractions for minor local needs (NRA 1994a). This situation is replicated in the Southern, Thames, Severn Trent and South West regions where the availability of water to meet new irrigation demand is severely constrained (NRA 1995c; NRA 1993c; NRA 1994c; NRA 1994d).

Against this background of restricted water supply availability, the demand for water is rising, specifically in the agricultural sector for use as spray irrigation and public water supply companies. Water companies represent by far the largest demand on resources, accounting for 51% of water abstracted nationally from non-tidal and groundwater sources (NRA 1994b). The level of industrial

and agricultural abstraction varies quite significantly across the regions with agricultural abstraction for spray irrigation concentrated in the Anglian and Severn Trent regions while industrial abstraction is concentrated in the North, Midlands and South Wales.

Licensed agricultural abstraction for spray irrigation has increased significantly, from a figure of 68ml/d in 1971 to 365ml/d in 1991 (Herrington 1996). In the Anglian region the rate of increase has been quite dramatic over the 10 year period 1982-1992, with the level of licensed abstraction increasing from 80,264 ml/pa in 1982 to 113,734 ml/pa in 1986 and 139,065 ml/pa in 1991 (see table 3.1 Part A); comparing these figures against the level of actual abstraction 1982-92 witnessed an increase of 266% (see table 3.1 Part B). The yield benefits of irrigation, particularly in a drought year provides a partial explanation for the rapid rate of increase. The drought of 1975-76 highlighted the benefits of irrigation through improved yields, which in combination with irrigation investment grants encouraged the expansion of irrigation in the late 1970s and early 1980s. Irrigation in this period concentrated on potatoes, fruit crops, sugar beet and grass land with some irrigation of cereal crops in exceptionally dry years (A.C.A.H.1980). Nevertheless, in the late 1980s a shift occurred away from irrigation purely for yield, towards greater emphasis on the

year	Anglian	North West	Northumbria	Severn Trent	South West	Southern	Thames	Welsh	Wessex	Yorks
1982	80264	-	-	35958	515	-	-	-	-	10101
1983	81870	-	227	37604	549	-	11060	4380	-	10897
1984	96871	-	357	39946	1132	-	11133	-	-	11274
1985	108077	-	439	-	1452	-	11461	-	7373	11791
1986	113734	-	526	48657	1495	-	11534	-	7300	14416
1987	119720	-	544	49463	1622	-	11644	-	7081	15248
1988	125195	-	572	50142	1651	-	11206	-	7227	17756
1989	128480	-	572	-	1663	-	10987	-	12629	18370
1990	132685	-	857	-	1701	-	10658	6205	12410	18933
1991	139065	-	857	-	1793	-	-	-	13578	20380
1992	-	5517	865	58953	2015	25894	-	7446	-	-

Table 3.1 Part A: Regional licensed abstraction spray irrigation (ML/pa)
(Source: Weatherhead *et al* 1994)

Year	Anglian	North West	Northumbria	Severn Trent	South West	Southern	Thames	Welsh	Wessex	Yorks
1982	23433	1058	-	9490	-	-	-	730	-	-
1983	33690	1314	64	12410	-	-	3066	730	-	2263
1984	38727	2117	91	-	-	-	3504	1460	-	-
1985	20842	913	42	6570	-	-	1679	730	1460	2482
1986	32923	913	135	13505	-	-	2409	730	2190	4380
1987	15367	474	17	9125	-	-	1971	730	2190	3468
1988	20805	547	35	9490	-	-	1880	4782	2993	4088
1989	53035	1241	162	26645	-	-	3176	2336	3796	7519
1990	77855	1431	166	24820	-	-	3796	2409	4453	8833
1991	85775	-	118	-	-	2931	-	2519	2774	9636
1992	-	-	-	-	-	2838	-	5475	-	-

Table 3.1 Part B: Regional actual abstraction spray irrigation (ML/pa).

(Source: Weatherhead *et al* 1994)

benefits for crop quality, particularly for high value crops such as potatoes, root vegetables and salad crops (Weatherhead *et al* 1994). Thus irrigation of sugar beet and cereal crops as well as grassland declined.

Irrigation is becoming an essential element of total crop management in order to conform to the changing demands of the agricultural market, and in consequence the demand for water for irrigation is projected to increase nationally by 1.7% pa to the year 2001 and then by 1% pa from 2001-2021 (Weatherhead *et al* 1994). These figures may appear small, but when examining them at the regional level the projected demand for irrigation represents a significant increase. In Anglian region demand is projected to increase by 60% in the year 2021; in Severn Trent by 38% and in Southern by 78% (see table 3.2).

Region	1990	1996	2001	2006	2011	2016	2021
Anglian	85641	99375	109267	117058	124088	130619	136681
North West	1566	1789	1984	2154	2322	2490	2656
Northumbria	201	227	241	253	264	274	283
Severn-Trent	27302	31257	33326	34781	35952	36946	37776
South West	2409	2650	2848	3028	3216	3413	3615
Southern	11644	12834	14902	16512	18028	19445	20759
Thames	5701	5314	5536	5639	5735	5829	5923
Welsh	2650	3034	3379	3670	3949	4219	4477
Wessex	4818	4915	5127	5312	5520	5744	5977
Yorks	9700	11484	12422	13193	13882	14520	15095
Total	151632	172879	189032	201600	212956	223499	233242

Table 3.2: Predicted irrigation volume 1996-2021 (ML/pa)

(Source: Weatherhead *et al* 1994)

These projected demand increases will therefore have a significant impact, particularly given the nature of the abstraction. Spray irrigation is concentrated in the summer and periods of exceptionally low rainfall, and on a peak day can exceed the rate of public demand for supplies. In addition, it is a wholly consumptive use of water with no return discharges to the river system. In consequence, the demand for water for spray irrigation places severe stress on ground and surface water sources at a time of the year when flow levels are at their lowest (NRA 1994b) and thus the potential for environmental damage is high. In light of this, EA policy in the Anglian, Southern and Severn Trent regions emphasise new licence applications for surface water can only be met through the construction of on-farm reservoirs, as abstraction in the winter months reduces the stress placed on the environment and ensures farmers have a reliable supply of water.

The primary component of demand in the public water supply sector is domestic consumption which accounts for 8,120 ML/day (OFWAT 1994a) and is largely unmetered (see table 3.3). Public water supply has increased dramatically over the past 20 years with an increase from 14,806ML/d in 1973-74 to 17,015ML/d in 1994-95 (WSA 1995) and is partly explained by the increased use of washing

machines, dish washers and the massive extension of garden watering (DoE 1996a+b; DoE 1992). Nevertheless, the increased demand on resources in this sector is not wholly the result of changes in domestic consumer behaviour. The level of distribution losses, or leakage levels, represents an important component of public water supply demand accounting for on average, 3,517 ML/day (OFWAT 1994a) or 22% of the water put into the supply system in 1994.

NRA REGION	PWS		INDUSTRY		SPRAY IRRIGATION		GENERAL AGRI.		ELECTRICITY	
	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW
Anglian	790	970	101	42	62	82	14	0	0	7
Northumbria and Yorks	338	1,892	69	487	21	7	6	-	5	249
North West	211	1,560	130	399	1	2	5	-	0	477
Severn Trent	966	1,528	90	317	27	40	5	1	3	1135
Southern	1,035	324	101	41	8	9	3	-	-	0
South West	427	927	32	128	3	103	36	32	2	1545
Thames	1,361	2,619	61	17	7	5	7	-	-	88
Welsh	133	1,654	38	552	1	6	6	-	2	4544
Total	5,261	11,474	622	1,983	129	155	83	35	13	7956

Table 3.3: Licensed water abstraction (Million litres per day)
(Source: DOE 1996a)

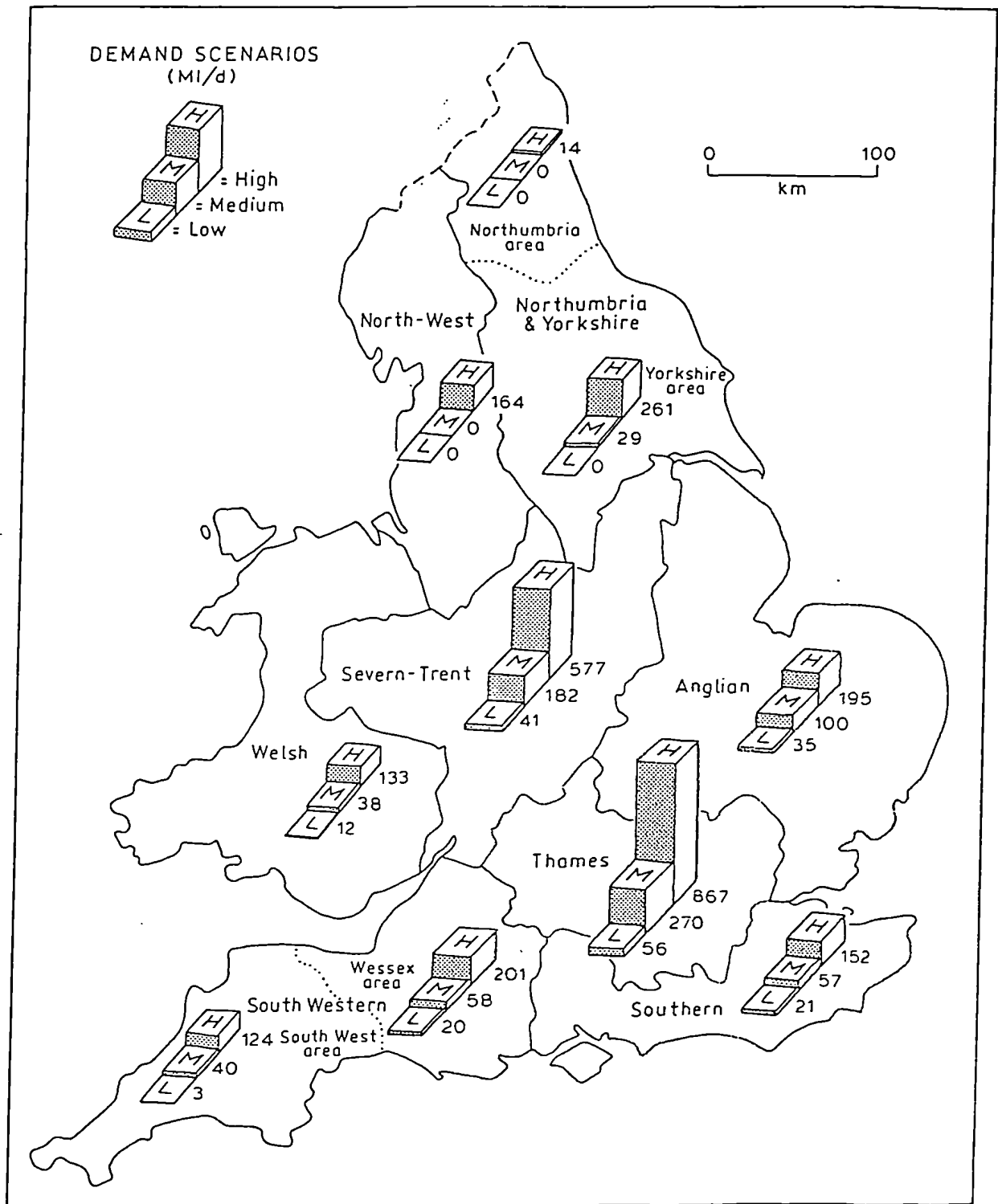


Figure 3.4: The growth scenarios(Increase in average public water supply demand to 2021 under a range of demand scenarios expressed as a percentage of 1991 demand.
 (Source: NRA 1994b)

The public water supply companies are under sustained pressure from the EA, environmental groups and the Labour Party to control leakage levels, and OFWAT (1994a) projects a reduction of 20.6% on 1994 leakage levels by the year 2014.

Notwithstanding these reductions, the level of demand for domestic water is forecast by EA, OFWAT and the WCs themselves to increase over both the long and short term. EA regional calculations suggest the demand increase will vary from between 18-37% for Anglian region or 3-28% for Severn Trent depending on the demand scenarios (see figure 3.4). Comparing these figures against the present levels of surplus resources (see figure 3.3) the margin is very tight, even when considering the low growth scenario. Nevertheless, a great deal of caution should be exercised when using these figures as recent history demonstrates the inadequacy of water demand projections (see Herrington 1996, for a full discussion). Calculating demand increases over the next 10 years in itself proves difficult; extrapolating these figures over thirty is definitely problematic and should provide only a bench mark figure.

The agricultural sector is also in competition with the environment over access to and use of reliable supplies of water. Allocation of water to safeguard the water environment has proved problematic, with some catchments suffering, even under normal weather conditions, from over abstraction whereby authorised abstractions exceed natural water availability. These conditions are inevitably exacerbated in drought periods, as demonstrated in 1988-92 with the complete drying out of rivers, such as the River Darent in Kent and the dehydration of wetlands. In 1991 the NRA published, a list of the top 40 rivers which were suffering from excessive abstraction (NRA 1993b). Twenty of these cases were scheduled for immediate action (see figure 3.5), and in most cases water company abstraction was identified as the primary factor contributing to over abstraction.

The catchments identified in the top 40 list represent only the tip of the ice-berg, with many more catchments and wetland sites suffering due to up-stream or ground water abstraction. NRA South West

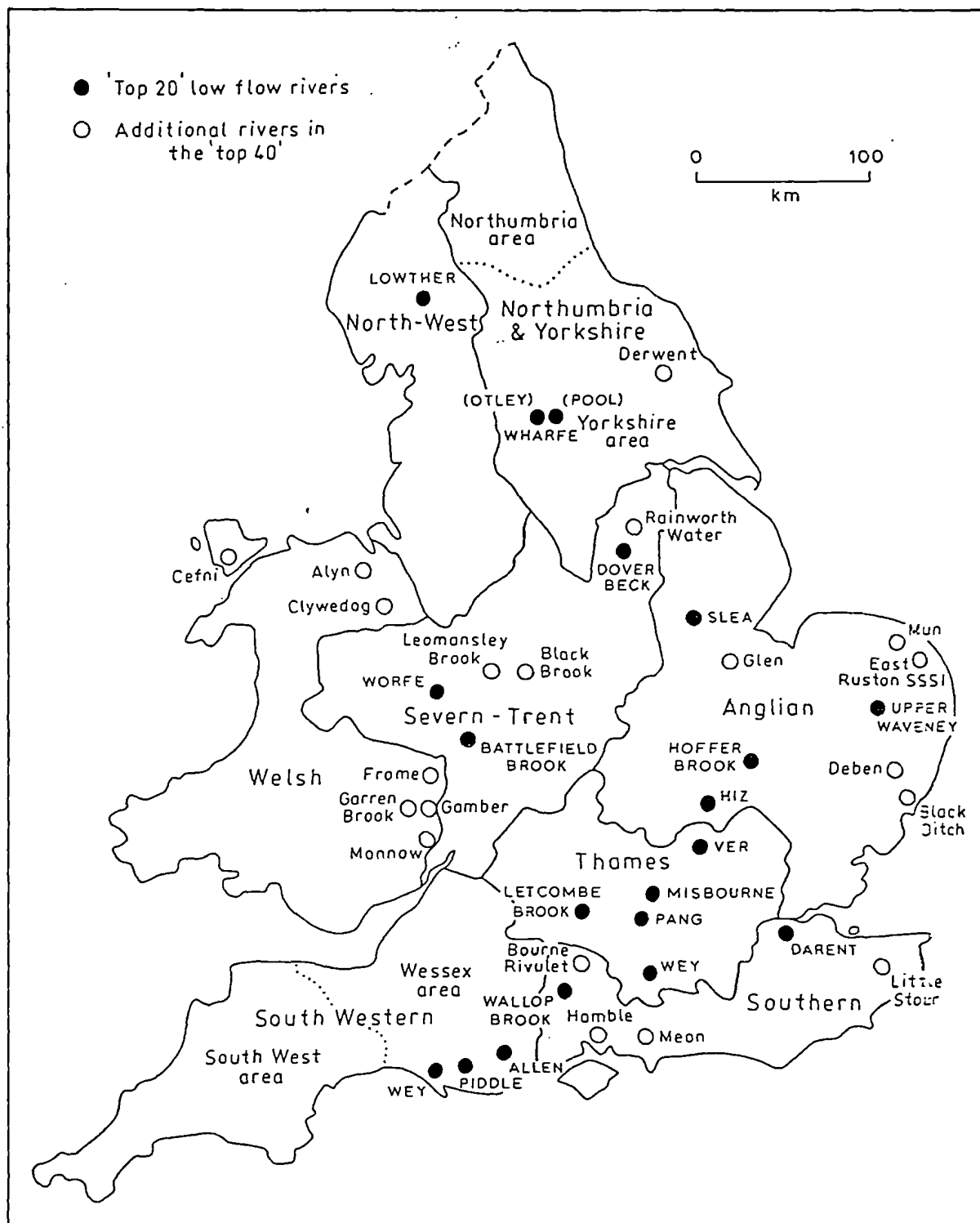


Figure 3.5: The top 40 over abstracted catchments in the UK.

(Source: NRA 1993b)

region identified 109 sites where adverse environmental effects were occurring (NRA 1992d), while Anglian region has identified a further 10 possible low flow rivers and wetlands (NRA 1994a). Severn Trent region has identified 14 ground water units suffering from over licensed abstraction, with an additional 12 over licensed but under abstracted units (NRA 1993c). These units represent significant environmental problems, particularly if currently under-utilised licences are brought into use, thus significantly upsetting the allocation of water to the environment and presenting a threat to the flow levels. These assessments do not include the views of other environmental groups, such as English Nature, the RSPB and the Wildlife Trusts whose own research presents a markedly worse situation. The Anglian region Wildlife Trusts for example identify an additional 108 wetland Sites of Special Scientific Interest and Wildlife Trust reserves under threat from dehydration (Beardall *et al* 1992). Research commissioned by English Nature underlines this with ground water abstraction identified as contributing to changes in the plant communities at 26 spring and wetland sites in Norfolk, Suffolk and Cambridgeshire (Wheeler and Shaw 1992). More recent work undertaken by English Nature in 1996 reports 89 out of 152 SSSIs investigated were at risk from over abstraction, now or in the future; while the RSPB (1996) concludes a total of 354 wetlands and rivers are either affected by over abstraction, or are at risk now or in the future.

It is evident that conflicts over access to, and use of, reliable supplies of water are becoming an increasingly critical issue, as the different users and uses of water compete for limited supplies of water. The conflicts of interest and value inherent in the allocation and regulation of water are not merely articulated at the institutional level, as the EA attempts to balance the different demands on water. At the local level farmers, environmentalists, Water Companies and the general public are becoming more acutely aware of the increased competition for water, particularly in the aftermath of the 1989-92 drought. Hence, this analysis will attempt to draw out these discontinuities and conflicts, particularly in relation to the allocation and regulation of water for use as spray irrigation. Three key areas are defined as central to this agriculture-water resource conflict:

(i) competition between water users over access to and use of reliable supplies of water.

Agricultural demand for water for spray irrigation competes with industry, public water supply companies and the environment over access to and use of water supplies.

(ii) introduction of stricter controls and regulatory measures to protect and/or enhance the *in-situ* water environment. Agricultural abstraction licences for spray irrigation are subject to stricter controls in order to protect specific environmental sites.

(iii) over-abstraction and low flow levels damaging the *in situ* water environment.

Insufficient water within the catchment to protect the *in situ* water environment or meet the demand for new supplies by industry, agriculture and public water supply companies.

These conflicts are most clearly exposed in the Anglian region, which, as the analysis underlines, combines the lowest annual average effective and drought effective rainfall levels in the UK with the highest levels of abstraction for spray irrigation use. Nevertheless, constraints of both time and money prevent a survey of all irrigation abstractors in the region, and in consequence the analysis will concentrate instead on abstractors in specific river catchments in the Anglian region.

River catchment areas are defined on the basis of discrete geographical areas (Parker and Penning-Rowse 1980; Newson 1993). These administrative units are defined on the basis of all or part of the river basin system from its source to the sea, and include both surface and ground water systems. Catchments are wholly administrative units used to manage in an integrated manner, water supply, water quality, flood control, the water environment, fisheries, and recreation. The inter-dependence between these core functions of water resource management led the NRA to develop integrated catchment management plans for 200 surface and ground water systems in the UK (Chandler 1994). These plans adopt an holistic approach and attempt to outline in detail the current and projected demands on the six core functions and reconcile the conflicts between

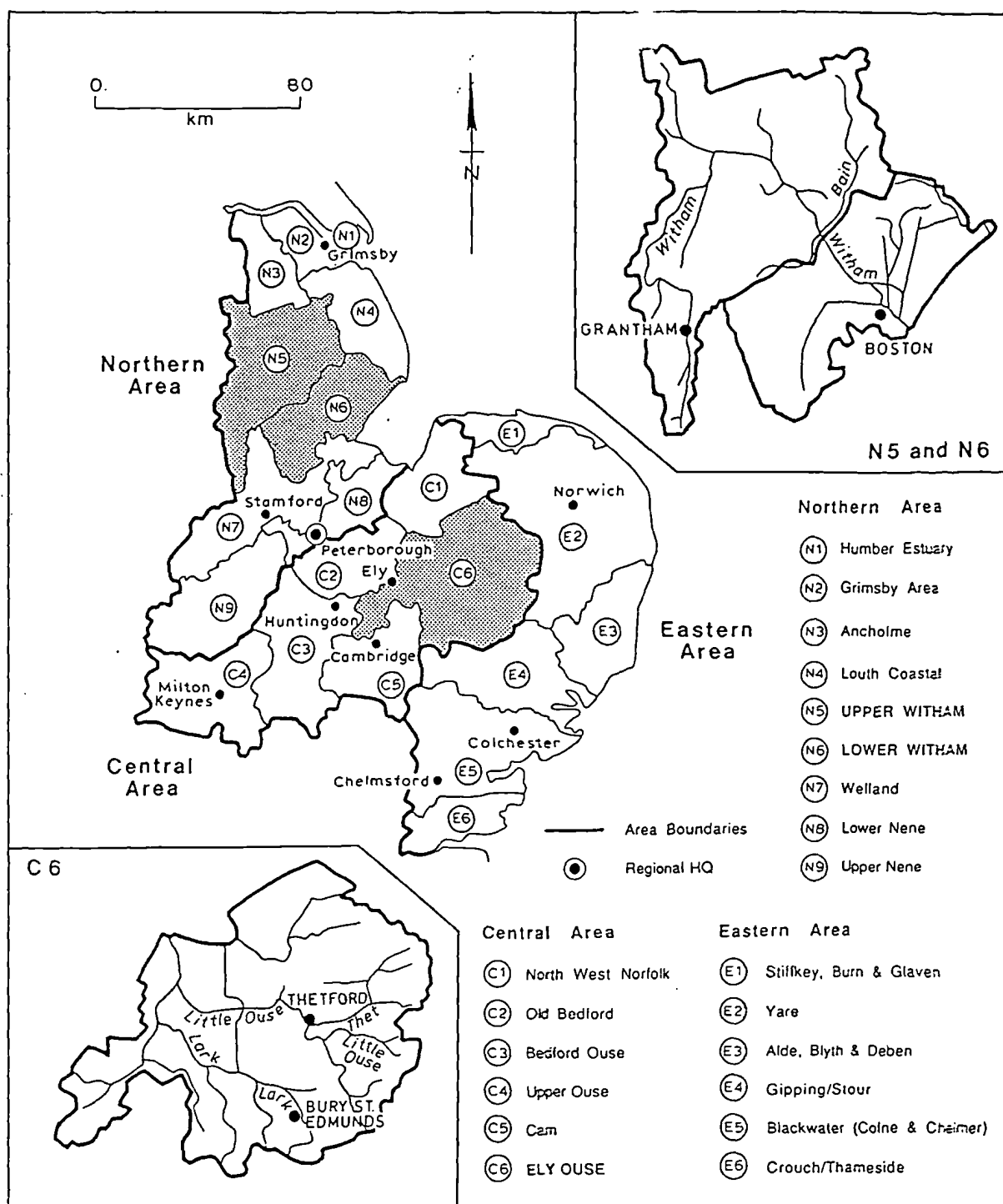


Figure 3.6: The catchment study areas.

them. The choice of catchment study areas was guided by secondary data sources and empirical analysis conducted under a project entitled The economic of water resource management, funded by the NRA⁶. Full access to all the empirical material gathered under this project was granted and provided an important input into the choice of research study areas, highlighting catchments suffering particular water abstraction problems.

Under the guidance of NRA officials and supplemented by information gathered in the Economics of water resource management project, four catchments were identified as possible research study areas: the Lark Valley; Thet-Little Ouse; Slea, and Bain-Witham and all reflect the three dimensions of the agriculture-water resource conflict. Irrigators in the Bain-Witham catchment were interviewed in the 1991-92 survey conducted by Rees *et al* (1993). Re-interviewing these farmers would provide a greater depth of understanding into the key processes influencing their use and management of irrigation water, with the added advantage that the respondents already knew the interviewer, and were therefore more likely to agree to a second interview. Further consultation with NRA staff and examination of the catchment management plans reduced the number of catchments to three: the Lark Valley in Suffolk, the Thet-Little Ouse in Norfolk and the Bain-Witham in Lincolnshire (see figure 3.6).

3.2.2: The Thet - Little Ouse Catchment.

The Thet-Little Ouse catchment is centred around the market town of Thetford in Norfolk (see figure 3.7) and roughly corresponds with the boundaries of the Government designated Breckland Environmentally Sensitive Area (ESA). The Breck heathland is unique in the UK, with flat sand land overlying a chalk aquifer with belts of Scots Pine and areas of heathland offering a rich diversity of

⁶ Rees, J., Williams, S., Atkins, J.P., Hammond, C., Trotter, S. (1993) The economics of water resource management, Bristol: NRA. From July 1991 to December 1992, I was employed as a research assistant on this project. I was directly involved in the design and implementation of surveys in the agricultural and industrial sectors on the use and management of abstraction water. I was also responsible for the analysis of the data.

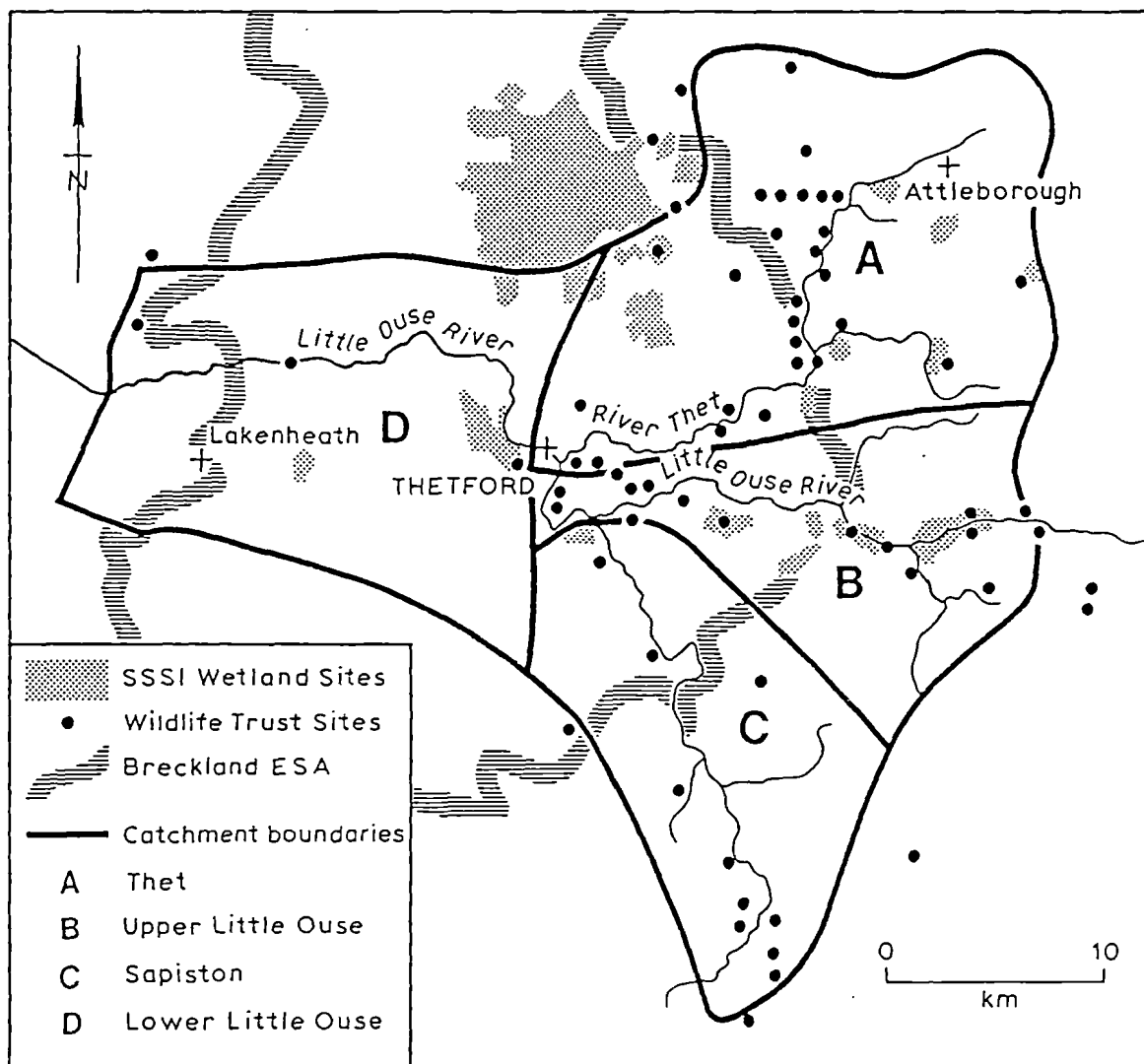


Figure 3.7: The Thet-Little Ouse catchment.

flora and fauna. 47 SSSIs have been designated, of which 23 are wetland sites with an additional 50 wetlands managed by the Wildlife Trusts (English Nature 1992). The key dimensions of the water conflict in this catchment centre on the protection of the water environment, in particular the Meres⁷ environment, while meeting increasing demand from agricultural spray irrigators and PWS companies for new supplies of water. The Breckland Meres are SSSIs which occasionally dry out naturally. However, under Section 57 of the 1991 Water Resources Act, the NRA are unable to use their statutory powers to impose restrictions on abstraction in drought periods to protect this unique landscape feature. Hence during the prolonged drought of 1989-92 the NRA had to revert to voluntary agreements with spray irrigators in order to protect the Meres from low flow levels and by implication long term ecological damage. Thus, within a 10km radius of the Meres voluntary restrictions were agreed on irrigation use and in the aftermath of the drought, the NRA are introducing cessation clauses into irrigation licences which come up for renewal. Thus, once the flow in the river falls below a certain, pre-defined level irrigation abstraction is automatically banned in order to protect the Meres from dehydration. Farmers use of irrigation in this catchment comes into direct conflict with the environment, as the NRA attempts to protect this unique landscape feature within the confines of its statutory powers.

	Gross Resource	Effective Resource tcmd	Committed environment tcmd	Committed abstraction tcmd	Balance nominally available	Best estimate water available
Bain-Witham	47.0	82.0	37.0	36.6	8.5	0
Lark	159.4	127.5	46.9	83.1	-2.5	0
Thet-Little Ouse	263.4	210.8	132.9	81.1	-3.6	0

Table 3.4 : Available groundwater resources in the three study areas.
(Source: NRA 1994a)

⁷ Meres are wetlands which occur when dips in the landscape intercept the water table.

The allocation of water resources in the catchment is finely balanced, with no additional ground water resources available for allocation (See table 3.4).

	Lark*	Thet-Lt Ouse*	Upper Witham**	Lower Witham ***
<u>PWS</u>			11874	13790
1966	12055.0	4459.6		
1976	20604.0	10014.3		
1986	19376.0	11213.6		
1991	22176.0	22849.5		
<u>Industry</u>			7663.5	854
1966	2194.23	94.00		
1976	4586.86	340.05		
1986	5543.02	962.65		
1991	6211.46	1882.95		
<u>Spray Irrigation</u>			6264	5400
1966	587.18	547.20		
1976	1544.4	1232.37		
1986	3110.33	6540.73		
1991	5075.95	6552.03		
<u>General Agri.</u>			222.7	99.0
1966	300.16	521.40		
1976	560.32	898.50		
1986	593.79	1445.2		
1991	712.68	1452.3		
<u>TOTAL</u>			26,024.7	20,309
1966	15,146.57	5622.2		
1976	27,295.58	12,485.15		
1986	28,623.14	20,162.15		
1991	34,176.09	32,736.78		

* Groundwater abstraction only.

** Surface and ground water abstraction 1996 only

*** Surface and groundwater abstraction 1993 only

Table 3.5: Historical licensed abstraction in the three catchment study areas (tcma).

Although only 30% of the gross resource is actually licensed, NRA calculations suggest over half of the groundwater resource should be reserved for the protection of flow levels in the River Thet (NRA 1994b). The allocation of licences has risen markedly since 1966 (see table 3.5) with PWS allocated the largest proportion of licences. In fact, Cambridge Water Company was granted 3 licences in 1990 to export up to 8518 tcm/a for use in Cambridge City. This represents a total loss for the catchment, as water companies normally return a proportion of their abstraction to the river of origin through the return of effluents via the sewage treatment works.

Given the light sandy soils which predominate in the catchment, agricultural demand for water for irrigation purposes is unlimited, although there is no publicly available data on the level of unmet demand. The EA recognises this demand can only be met through the construction of on-farm water storage facilities, and therefore no new summer abstraction licences are available. Thus, this catchment conforms with two of the critical dimensions of the conflict catchment methodology, namely agricultural demand for water comes into direct competition with the requirements of the *in situ* environment; and new and tougher restrictions are being introduced into irrigation licences to protect the environment.

3.2.3: The Lark Valley Catchment.

The Lark Valley catchment area lies adjacent to the Thet-Little Ouse catchment, with Bury St. Edmunds located at its centre (see figure 3.8). The catchment stretches from Bury St. Edmunds to Mildenhall and Lakenheath in the north-west where the Lark river flows into the fen system of the Bedford level. The northern reaches of the catchment fall in the Breckland ESA, and there are 6 water dependent SSSIs and 12 wetlands managed by the Wildlife Trust. Flat sand land and chalk heathland predominate in the catchment which overlies the chalk aquifer. The flow of the River Lark is highly dependent on base flow from the chalk aquifer and effluent discharges. During the drought of 1989-92 low flow levels developed in the river and in fact part of the river has now been designated a “possible low flow”

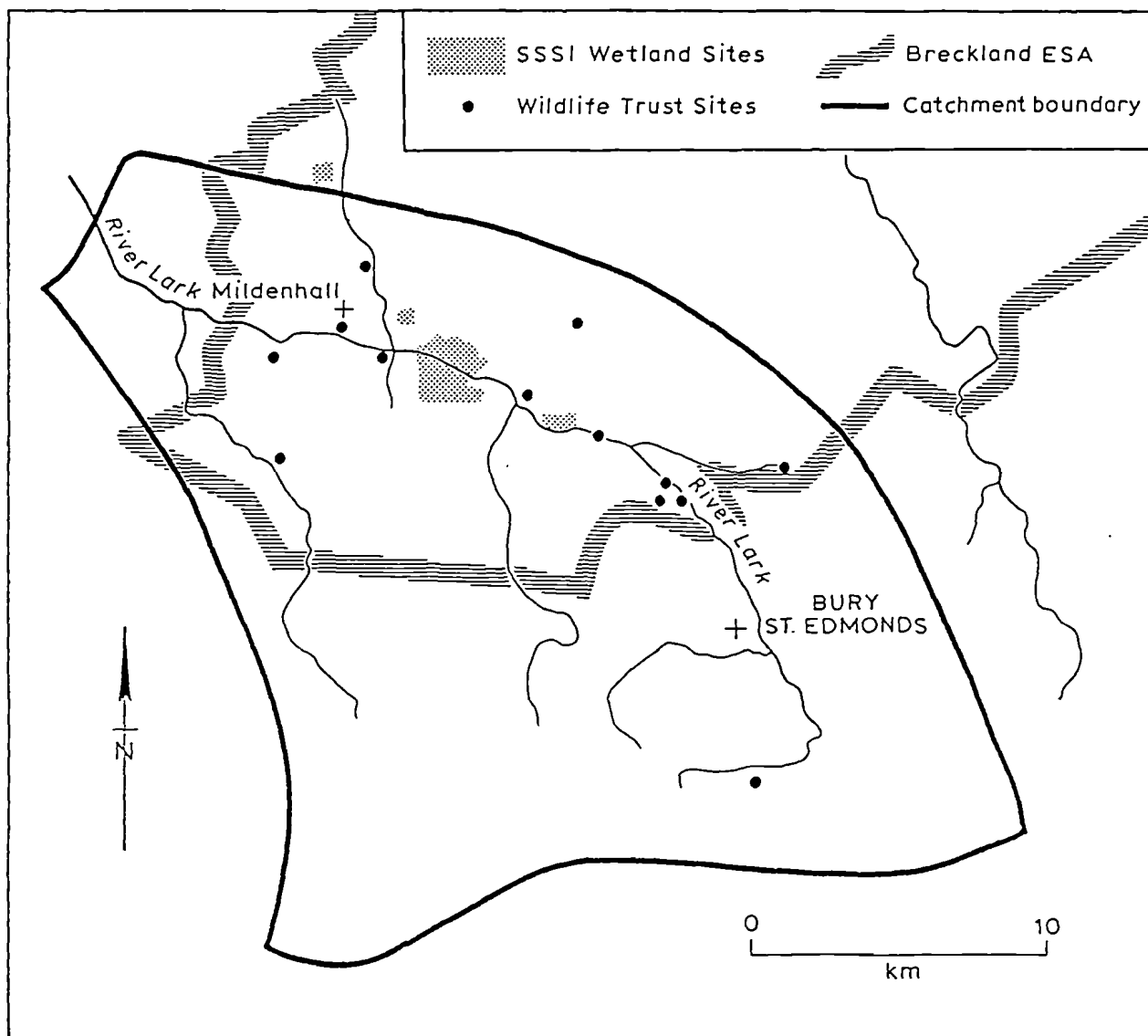


Figure 3.8: The Lark catchment.

river by the NRA (NRA 1994a). Effective resources in the catchment are fully committed, with no additional resources available for allocation (NRA 1994a) and so new irrigation licences are confined to water storage facilities. In fact the Lark catchment has a resource deficit of -2.5 tcmd when licensed abstraction and in stream river allocation are subtracted from the effective resource (see table 3.4). This situation is further complicated by the fact that sub-units of the catchment are over licensed, with the licensed quantity of abstraction greater than the available resource.

Under the guidance of NRA officials it was decided not to interview all irrigators in this catchment, as this would include abstractors on the River Kennet. Instead, work concentrated on the sub-units of the River Lark namely sub-units A, B, and C on figure 3.8.

Once again the level of licensed abstraction has risen markedly since 1966 (see table 3.5), with spray irrigation licences now accounting for 10.56 tcmd. During the drought period of 1989-92 abstraction bans were imposed under Section 57 of the 1991 Water Resources Act. Total abstraction bans were imposed on surface spray irrigation licence holders in 1990, followed in 1991 by 50% and then 100% bans on groundwater abstractors. Voluntary restrictions were agreed between the NRA and all spray irrigators in the catchment in 1992. Press reports (Pollitt 1991; East Anglian Daily Times 23.7.91; East Anglian Daily Times 21.8.91) highlighted the level of opposition to abstraction bans among farmers in the catchment, and identified movement towards a “farmers’ group” to negotiate collectively with the NRA over access to and use of water for spray irrigation purposes. This catchment conforms to two of the key conflict catchment criteria, with increasing competition and conflict between users over access to and use of reliable supplies of water, which is further compounded by the limited supplies of water to protect in stream flow levels.

3.2.4. The Bain-Witham Catchment

The Bain-Witham study area falls within the Upper and Lower Witham catchments in Lincolnshire (see figure 3.9), and is centred on the city of Lincoln and market town of Horncastle. These catchment sub-units incorporate chalk heathland and fenland and encounter distinctly different water resource management conflicts including groundwater pollution; low river flows and the consequent impact on the *in situ* environment; the refusal of new summer spray irrigation licence applications; restrictions on abstraction from the Lincolnshire Limestone aquifer and the threat of abstraction bans or restrictions.

There are 38 designated SSSIs and 28 Nature Reserves in the catchments, with the north-eastern part of the Upper Witham coinciding with the boundaries of the Wolds Area of Outstanding Natural Beauty (ANOB) and Area of Great Landscape Beauty. The Upper Witham catchment also incorporates the boundaries of the designated Nitrate Vulnerable Zone (NVZ) at Lincoln, and the Nitrate Sensitive Area (NSA) designation at Branston Boothes, where voluntary schemes have been introduced by MAFF to control the pollution of groundwater from nitrates, pesticides and herbicides leached from agricultural and other land. Water resources within the Upper and Lower Witham catchments can be augmented by the transfer of water from the River Trent via the Fossdyke canal. This transfer scheme is licensed to abstract 41,059 tcma (EA 1996c) which provides water for four main users:

- (i) abstraction at Short Ferry to meet abstraction and environmental needs from the River Ancholme;
- (ii) abstraction of water to meet spray irrigation and industrial demands for water from the River Witham;
- (iii) dilution and flushing of saline water from the lower reaches of the Witham by maintaining a residual flow to tide;
- (iv) maintaining navigation levels and supporting fishing, recreational and environmental uses on the River Witham (EA 1996b).

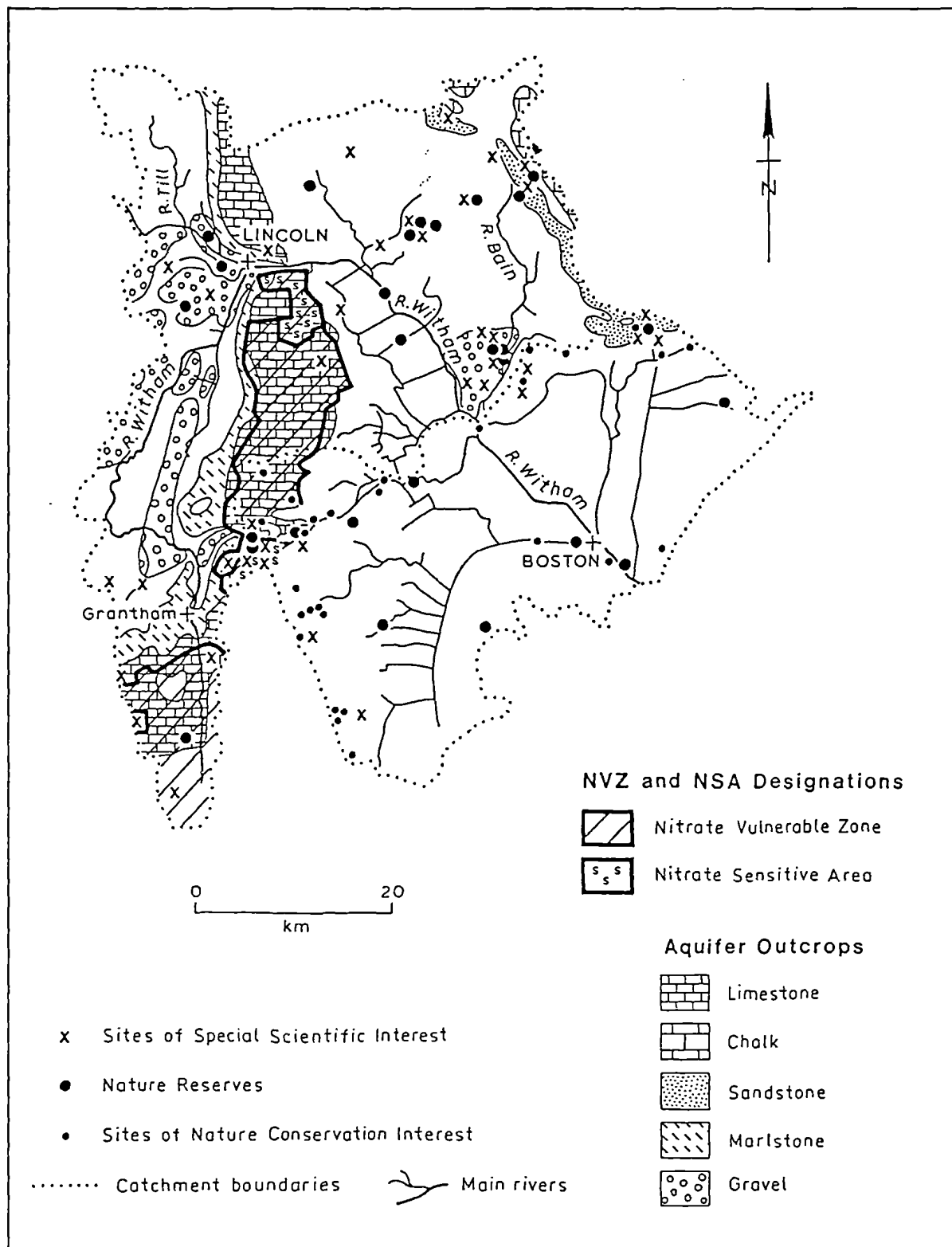


Figure 3.9: The Bain-Witham catchment.

Licensed abstraction from surface and ground water sources in the Upper and Lower Witham are dominated by public water supply which accounts for 11,874 tcma in the Upper and 13,790 tcma in the Lower Witham (see table 3.5). Spray irrigation in both catchments accounts for 24% and 27% of total licensed abstraction, which represents 6264.5 tcma in the Upper Witham and 5,400 tcma in the Lower Witham. The level of actual abstraction varies quite significantly, with the figures for the Upper Witham revealing the marked differences between dry and average year abstractions with spray irrigators actually abstracting 3204 tcma in 1990, classified as a dry year, compared to 2305 tcma in 1994 an average year and underlines the potential for reallocating under- or un-utilised licences. Rather than surveying all irrigation abstractors in the Upper and Lower Witham, analysis will focus on two sub-units in these catchments namely the River Bain and the River Witham.

There are a number of conflicts over access to and use of water within the River Bain. Firstly, licences of right allowing the abstraction of surface water for spray irrigation purposes, have created particular problems in periods of drought, leading to low river flows and concerns for the *in situ* river environment. These licences do not include cessation levels, which automatically restrict abstraction when river flows fall below a pre-defined level. In consequence, no new summer spray irrigation licences are permitted in the Bain, and farmers are encouraged to construct on-farm water storage reservoirs (EA 1996b). The second critical problem in the Bain concerns groundwater abstraction from the Bain gravels, which extend along the lower reaches of the river and cover an area of 77km². The deposits are relatively thin and summer flows in consequence are very low, so there are strict cessation levels on all renewable spray irrigation licences in order to prevent damage to the *in situ* environment which includes a number of SSSIs. Thus, farmers are faced with high levels of uncertainty over the reliability of water supplies and the threat of restrictions or complete bans are ever present.

The River Witham combines chalk heathland and fenland, with farmers licensed to abstract water from the Lincolnshire Limestone aquifer and the dykes and ditches of the fenland drainage system. The resources of the Lincolnshire Limestone are fully committed and no additional water is available for

allocation. This aquifer has also been classified under the NRA Groundwater Protection Map, as susceptible to pollution and already has high concentrations of nitrates, pesticides and herbicides which exceed the limit of 50mg/l. NSA and NVZ designations fall on this aquifer and farmers are able to adopt voluntary measures to reduce the threat of leaching. Surface water abstractions in the River Witham are augmented through the transfer of water from the River Trent, which maintains flows throughout the summer for spray irrigation abstraction. In fact, one group of farmers negotiated collectively with the NRA to secure the transfer of additional water for abstraction in the West Fen Drainage area, with farmers paying £1,000 for membership of the Water Transfer Company. This represents an important collective response by farmers to the problems of unreliability of supply and abstraction restrictions. The Rivers Witham and Bain provide critical insight into the conflicts experienced in the allocation and regulation of abstraction water between competing users and uses. Unreliability of abstraction supply was an established feature in these catchments, long before the drought of 1989-92, and therefore provides key insights into how farmers respond at the farm level to changes in the availability and reliability of water.

The three study areas are all located in the Anglian region, and all address different dimensions of the conflict inherent in the allocation and regulation of water for use as spray irrigation. By concentrating research in these specific areas it is possible to expose how competing actors with different interests and values in water and the water environment, shape not only the direction of water policy at the local level but also influence the response of the regulated to specific policy initiatives. These processes have critical implications for the environment and by concentrating on specific catchments it is possible to track, at the local level, the key processes perpetuating the dynamic displacement of environmental problems from one media, time or place to another. This approach will also enable analysis to trace the potential impact of demand management policies on inter-dependent economic and environmental systems, exposing the unintended consequences and side effects which potentially result from policy intervention.

3.3 Empirical Strategy

The empirical strategy which developed in light of the conceptual approach outlined in section 3.1 is necessarily complex and the work was divided into two phases. Phase one concentrated solely on understanding the web of social relations within which farm businesses are embedded, focusing particularly on the implications which these internal and external relations have for the management and use of irrigation water. This necessarily requires a survey of farm businesses. The second phase of analysis attempts to identify key agents from the State, market and social spheres of regulation who directly and indirectly influence on-farm irrigated production, through controlling the flow of information and capital to the farm. Interviews with these agents were supplemented with secondary data sources such as company reports, NRA official reports and published statistics. The time frame in which the empirical work was conducted may critically influence the response of individuals and firms to questioning. The prolonged drought of 1989-92 had forced water issues onto the national political agenda and many farmers had to critically re-evaluate their perception and valuation of water. This survey was conducted in the aftermath of the drought, in 1994 when the “crisis” over access to, and use of, reliable supplies of irrigation water had dissipated and was not an immediate issue for farmers at the local level.

3.3.1 Phase one: The farm survey

The farmer is the critical point of entry in opening up, for analysis, the complex web of State, market and social forces of regulation which directly and indirectly impinge on their irrigation decision making. Tracking the competing and conflicting signals which impinge on and distort irrigation decision making it is possible to understand the complex processes which together influence the use and management of irrigation water. Distinguishing three simple phases as water passes in, through and out of the production system, enables clear identification of the dynamic processes which together influence the transformation of ‘water’ as it enters and leaves the production system, revealing the complex trade-offs which influence farmers’ perception and valuation of access to and use of reliable supplies of water. The farm survey has three primary objectives:

(i) to focus on farmer knowledge and perception of water, water rights and the water environment. These frameworks of understanding provide key insights into the way in which farmers formulate and implement irrigation management strategies in response to external forces of change;

(ii) examine the way in which State, market and social forces of regulation directly and indirectly penetrate on-farm production decision making. Identifying the network of social relations principally concerned with irrigated production focuses on the form and function of farmers' relationship with irrigation advisers, irrigation equipment manufacturers and marketing outlets for irrigated produce. Through examining the flow of information and capital between the farm and these external agents, it is possible to examine how these agents directly and indirectly regulate farmers' use and management of irrigation water. The degree to which farmers conform to, and actually incorporate, these new ways of doing things into their own management practices is critical;

(iii) finally the survey aims to examine farmer negotiation and representation with the NRA and Government over access to and use of reliable supplies of irrigation water.

Defining the sampling methodology is the first stage of any survey work, and the principles which underpin this process emphasises the importance of avoiding bias in the selection procedure (Moser and Kalton 1971). The design of the sampling methodology is critically influenced by the nature of the sample frame. Given the paucity of publicly available MAFF information on irrigation in the UK as well as the limited number of empirical studies on irrigation by academics, potential sample frame sources are very limited. NRA data on irrigation in the UK is limited to abstraction licence details and no information is recorded on the crops which are actually irrigated. In consequence, it is impossible to design a sample frame focusing solely on one commodity complex, such as irrigated potatoes or

salad crops. In light of these problems, the target population was necessarily defined as all agricultural spray irrigators in the three catchment areas to enable the use, as a sample frame, of NRA licence data. These listings record not only the name and address of all abstractors in the catchment but also document the licence abstraction details. Thus information on the licence size (tcma), source (ground or surface water), season (winter, summer or all year), use (industry, agriculture, spray irrigation, private supply, PWS) and type (licence of right, renewable licence) are readily available.

There are however, a number of problems associated with the use of these listings. Firstly, an element of variability is introduced into the sample design, as spray irrigators range from potato, root crop and dairy farmers to fruit and horticultural growers. As the EA does not record information on the actual use of spray irrigation, it is impossible to control for this level of variability in the sample frame design. Secondly, although the listings identify all agricultural spray irrigation licence holders in the catchment this does not necessarily correspond with the number of actual irrigators. A number of farmers hold onto licences, even though they don't irrigate, to enhance the land value or ensure flexibility in future production (Rees *et al* 1993). In addition the licence details are often dated and thus it is difficult to actually trace all named licence holders. In fact Rees *et al* (1993) were unable to trace 25% of licence holders identified in their sample frame. Given these problems it was decided not to set up a strict sampling procedure either randomly selecting licence holders from the list or stratifying the sample on the basis of the size or type of licence⁸. Instead all licence holders identified on the NRA list were included in the sample population with the clear expectation that a proportion of licence holders would be eliminated on the basis they were non users or were untraceable. In total 124 farms were included in the sample frame (see table 3.6 Part A) and the target sample size was calculated as roughly half of the sample frame population, in total 60-70 interviews across the three catchments.

⁸ This sampling procedure was applied in the Bain Witham catchment in the Rees *et al* (1993) study. The original sample was stratified into two groups: those who had invested in on-farm water storage facilities and a parallel set of farms who held summer abstraction licences from surface water sources. In total 20 were interviewed in this catchment in 1991. These farmers were included in the 1993-4 sample population which was extended to include all agricultural spray irrigators including ground water spray irrigators in the catchment.

	Part A	Part B		Part C				
	Sample Frame*	Interviews Completed	Refusals	Unable to locate	Never used licence	Unable to interview in period	Sold land	Refused explanation
Bain- Witham	51	31	20	4	8	0	0	8
Lark	43	19	24	7	7	5	0	5
Thet-Little Ouse	30	12	18	7	4	2	2	3
Total	124	62	62	18	19	7	2	16

Table 3.6: Phase One sample frame and completed interviews.

* These figures differ from the number of actual spray irrigation licences allocated in the catchments, as farmers hold multiple licences.

The second stage in the research design process concerns the choice of research tools used in the field. A number of complex issues were pinpointed in the research objectives focussing on farmer knowledge, perception and decision making processes in response to the conflicting signals emanating from State, market and social forces of regulation. Clearly these issues are not amenable to simple unequivocal answers and disentangling farmers' responses through highly structured questionnaires or postal surveys would provide only a superficial understanding of on-farm irrigation management practices. In consequence a review of the literature (Moser and Kalton 1971; Gilbert 1993; Bremer 1987; Mushler 1986) identified focused interviews as the most appropriate research tool, allowing in-depth discussion of a limited number of pre-defined topics.

Focused interviews are in essence a 'guided conversation' (Lofland 1971), with a set number of topics which the interviewer wants the respondent to talk about. The interviewer is free to phrase the question as they wish, ask the questions in any order and probe the respondent to provide fuller explanations of their behaviour (Fielding 1993a). An interview guide takes the place of a standard questionnaire and sets out the topic headings which the interviewer must address. The interview guide is reproduced in Appendix A. Eleven key topic headings were defined, including a section requiring quantitative data

on the nature of the farm business. Key questions were outlined under each of these topic headings to ensure some degree of comparability between respondents. Nevertheless, these only acted as a guide or introduction to the topic area. Each interview was taped; thereby the interviewer was not distracted by writing notes and enabled full participation in the conversation. Although this is a highly labour intensive research method, as the tapes must subsequently be transcribed, the benefits are evident in the rich and detailed information provided by the respondents. A diary recording the main themes from each interview supplemented the transcripts. This proved a useful tool, building up a picture of the key issues and themes as they emerged from the interviews.

In line with standard practice (Fowler 1988) the interview guide was piloted in the Bain-Witham catchment, where it was administered to 6 farmers. These interviews tested the draft interview guide, and full verbatim transcription of these interviews highlighted topic areas which needed more rigorous probing by the interviewer. In fact, the section on the perception of water and the water environment proved problematic, as the farmers seemed unwilling or unable to provide clear responses to questioning, despite probing. In consequence an additional set of questions were included which attempted to reveal indirectly farmers' perception and knowledge of water and the water environment. These questions took the form of hypothetical scenarios, where farmers were asked to outline how they would respond to changes introduced into their abstraction licence to protect the interests of other water users and the water environment. This line of questioning provided a clearer response from farmers and was included in the final interview guide.

Interviews were successfully completed with 62 farms between January and April 1994 (see table 3.6 Part B). Originally the target sample population was 70 farms; however, it was judged that the costs of prolonging the attempt to secure additional interviews outweighed the benefits of a marginal increase in final sample size⁹. As expected a large proportion of the licence holders were untraceable¹⁰ (18 in

⁹ The fact that farmers themselves were becoming increasingly busy, planting potato crops etc. made it difficult to find a convenient time to interview, despite their willingness to participate in the survey.

total) or never used their licence (19 in total) (see table 3.6 Part C). Significantly, seven farms in the Bain-Witham catchment had given up irrigation since the initial survey in 1991. Interviews with these farmers, where possible, were completed in order to gain an understanding of the combination of factors which influenced the movement out of irrigated production.

The response of the farmers to the focused interview was positive, and only three farmers refused to be taped. Interviews lasted on average between 60 and 90 minutes, although in some cases the interviews lasted over 2 hours. The focused interview proved the most appropriate research tool, with farmers willingly talking about a number of very complicated issues. Full verbatim transcriptions of all interviews were completed before the commencement of phase two of the empirical work. This strategy ensured full knowledge of all transcripts and enabled the identification of key questions for the second phase of interviews.

3.3.2: The general characteristics of the farm sample.

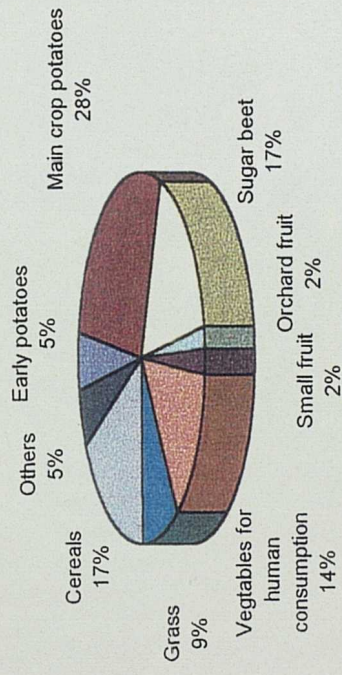
Irrigation in the UK is primarily concentrated on the potato crop which accounts for 44% of the total volume of water applied to crops nationally. Other vegetable crops, sugar beet, orchard fruit, soft fruit and grassland make up the remaining area, with a marked decline in the area of irrigated grassland occurring nationally (see figure 3.10). These trends are broadly replicated in the farm sample, where a total of 62 interviews was completed in the three study areas, with the majority of farmers (38) producing high value potato and vegetable crops. Of the remaining twenty four farms, two are dairy units using irrigation to guarantee production of silage crops; three are fruit farms using irrigation to guarantee fruit quality and yield and six produce flowers or garden plants in specialist units. The remaining thirteen farms hold licences, but don't actually irrigate concentrating instead on their arable and livestock enterprises, and in fact seven farms stopped irrigating in the aftermath of the drought of 1989-92.

¹⁰ Every attempt was made to trace licence holders: sending additional letters; visiting the farm address; cross checking with other interviewees in the locality.

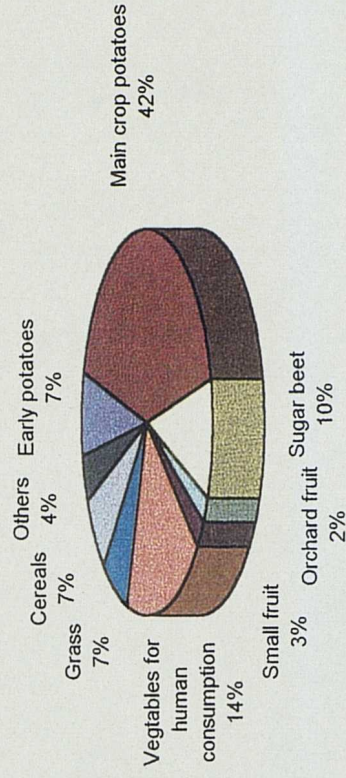
Quantity MI	All	Lark	Thet-Little Ouse	Bain-Witham
0 - 0.1	0	0	0	0
0.1 - 2	4	2	0	2
2 - 5	3	2	1	0
5 - 10	5	1	0	4
10 - 25	11	2	1	8
25 - 50	11	2	1	8
50 - 100	9	2	3	4
100 - 150	4	1	1	2
150 - 200	7	2	3	2
200 - 500	7	5	2	0
500 - 1000	2	0	1	1
n	62	19	12	31
Sum	6761.63	2187.9	2191.1	2090.79
Mean	109.06	115.15	182.5	67.44

Table 3.7: Total licensed quantity (megalitres)

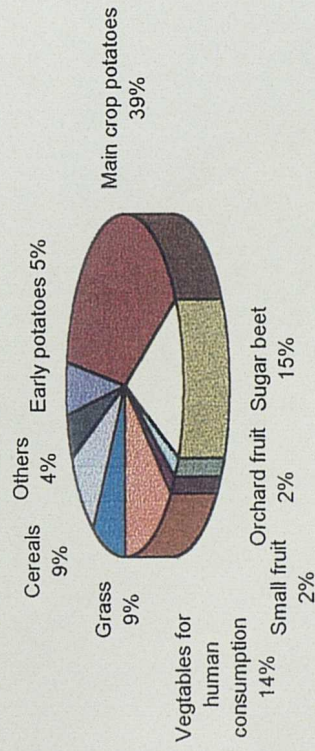
Proportion of total irrigated area by crop (1990)



Proportion of total irrigated area by crop (1992)



Proportion of total volume of water applied by crop (1990)



Proportion of total volume of water applied by crop (1992)

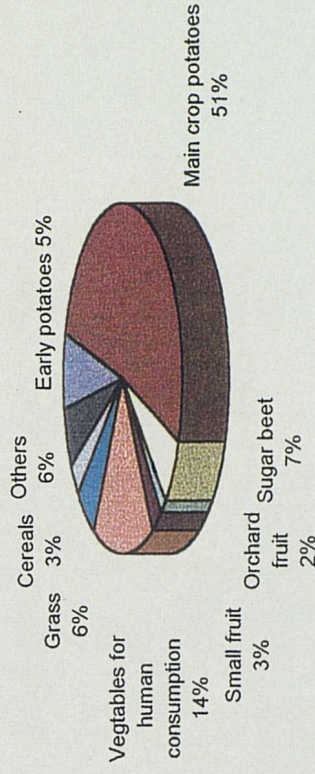


Figure 3.10: National distribution of irrigated crops.
(Source: MAFF 1991, 1993)

The total licensed quantity of water allocated to farmers in the sample averages 109.06 megalitres and ranges from a low of 0.1 megalitres to a high of 841.5 megalitres (see table 3.7). There are marked differences between the three study areas, with 58% of farms in the Thet-Little Ouse licensed to abstract over 100 megalitres of water, compared to 42% in the Lark and only 16% in the Bain-Witham, where farms are concentrated in the 10-100 size band. Unsurprisingly, there is a marked difference between the licensed and actual quantity of water used, reflecting the under- or non-

Quantity Ml	Licensed Abstraction	Actual Abstraction
zero	0	13
0.1 - 2	4	3
2 - 5	3	3
5 - 10	5	6
10 - 25	11	10
25 - 50	11	4
50 - 100	9	11
100 - 150	4	5
150 - 200	7	3
200 - 500	7	3
500 - 1000	2	1
	62	62

Table 3.8 : Licensed and Actual Abstraction (megalitres).

utilisation of water resources in the three study areas (see table 3.8). In fact a total of 13 farms do not use their licences and have not done so for a number of years. Water resources are also under-utilised with farmers rarely using in excess of 70% of their licence in drought years. This in part reflects rotational restrictions, changes in the cropping pattern and the overestimation of water requirement included in the initial licence applications, and underlines the significant potential for the reallocation of water to alternative users and uses.

Part A: Licence Type	
Licence of Right only	15
Renewable licence only	16
Licence of Right and Renewable licence	31
Part B: Licence Season	
Winter only Licence	6
Summer only Licence	37
Winter and Summer Licence	19
Part C: Reservoirs	
None	37
One	19
Two	4
Three	2

Table 3.9: Licence details.

The sample is split equally between multiple and single licence holders, with a total of 15 farms holding licences of right and an additional 16 holding a combination of licences of right and renewable licences (see table 3.9 Part A). In fact, of farms holding only renewable licences, 12 have invested in winter storage facilities as they attempt to improve on the reliability of summer abstraction licences. Nevertheless, only 25 farms in total have invested in a reliable supply of water by constructing winter storage facilities and, of these, 22 are located in the Bain-Witham and only 3 in the Lark catchment. These differences can be partly explained by two simple points. Firstly, farmers in the Bain-Witham study area abstract primarily from surface water sources which routinely suffer from low flow levels in the summer months, thus unreliability of abstraction supply is an established feature of the growing season. In contrast, farmers in the Thet-Little Ouse and Lark are reliant on abstraction from ground water sources. Unreliability of abstraction supply has not been perceived as a problem by the farmers themselves, and the drought of 1989-92 was the first time they experienced formal abstraction bans. Secondly, the topography and geology of Lincolnshire favour the construction of cheap reservoirs. In fact 7 farmers in the Bain-Witham have been able to construct reservoirs in conjunction with sand and gravel extraction companies, where in return for the commercial rights to the sand and gravel, the

extraction company agrees to ensure the excavated pit is suitable for on-farm water storage. The flat, sand land which predominates in the Lark and Thet-Little Ouse catchments provides few cheap, natural reservoir sites and thus farmers have to rely on rubber lined reservoirs which are significantly more expensive.

Farm size varies quite dramatically across the sample, from units of less than 5 hectares to large estates approaching 5,000 hectares (see table 3.10). However, caution should be exercised when interpreting these figures, as small land holdings often represent highly water intensive horticultural units, and in fact the six units producing flowers and plants are all less than 10 hectares and when these units are excluded, the average farm size is 472.7 hectares. Break-down of the sample into the three study areas reveals marked differences in size, with farms in the Lark catchment averaging 189.52 hectares, while in the Bain-Witham the average size is 551.61 hectares, and these differences are partly explained by the presence of large estates covering more than 2,500 hectares in the Lincolnshire study area. Land ownership predominates in the sample, with less than 5,500 hectares actually rented under formal tenancy agreements (see table 3.11). Despite this, in the Lark and Thet-Little Ouse catchments, renting out land under formal and informal agreements accounts for 1800 hectares, reflecting the local market for rental of sand land with water rights attached (see section 6.1.4 for full details).

Part A: Farm Size (ha)	All Farms	Lark	Thet- Little Ouse	Bain- Witham
0 - 5	5	2	0	3
5 - 10	1	1	0	0
10 - 50	7	4	1	2
50 - 150	12	3	1	8
150 - 250	10	4	4	2
250 - 500	11	3	2	6
500 - 1000	10	2	1	7
1000 - 1500	2	0	1	1
1500 - 2500	1	0	1	0
2500 - 5000	3	0	1	2
n	62	19	12	31
Sum	26516.7	3,601.2	5815.5	17,100.11
Mean	427.68	189.53	484.62	551.61
Part B: Total irrigated area (ha)	All Farms	Lark	Thet- Little Ouse	Bain- Witham
0 - 5	16	4	2	10
5 - 10	1	0	0	1
10 - 25	12	4	0	8
25 - 50	14	6	4	4
50 - 75	4	0	0	4
75 - 100	5	1	2	2
100 - 150	6	2	3	1
150 - 250	2	2	0	0
250 - 500	0	0	0	0
500 - 1000	1	0	0	1
1000 - 1500	1	0	1	0
n	62	19	12	31
Sum	3305.5	770.7	1545.7	989.4
Mean	53.31	40.5	128.1	31.91
% of TUA	66.11%	21%	21%	5.7%

Table 3.10: Farm size and total irrigated area.

	hectares
Area Owned	22839.41
Area rented in formal	5382.20
Total	28221.61
Area rented out formal	1214.10
Area rented out informal	534.44
Sub total	26473.07
Total utilised area	25903.74
of which	
arable	24049.33
Horticulture / fruit	163.59
Permanent pasture	1690.86
Remainder buildings, roads, woods	569.28

Table 3.11: Land tenure and land allocation.

42 farms grow potatoes which total 1491.6 hectares and account for 46.6% of the total irrigated area (see table 3.12). Root vegetables, namely carrots and parsnips, are the second and third largest irrigated crops representing 17.2% and 16% of the total irrigated area respectively and are wholly concentrated in the Lark and Thet-Little Ouse study areas. Onion and broccoli, both high value crops, are also entirely under irrigation and make up 7% and 5% of the total irrigated area. Irrigation of orchard and soft fruit crops is concentrated on just three enterprises in the Lark catchment, and the entire area of apples, pears and soft fruit are irrigated, although not for frost protection. Flowers are grown on three farms, where they make up 12.4 hectares and are also concentrated in the Lark catchment. These three enterprises grow a variety of flowers including Statice and Sweet William which are all irrigated. The final irrigated crop is forage maize, which is grown for silage feed on the two dairy farms in the sample and these farmers have both switched into maize production, rather than irrigating grassland, as it is tolerant to drought conditions. Thus, none of the farmers irrigate grass, reflecting the national decline in the area irrigated.

	Total area	Total area irrigated	Proportion crop area irrigated	Proportion of total irrigated area
Early potatoes	269.12 (8)	269.12	100%	8.3%
Main potatoes	1222.52 (35)	1222.52	100%	38.0%
Apples	113.70 (3)	113.70	100%	4.0%
Pears	23.31 (2)	23.31	100%	0.7%
Soft fruit	5.53 (3)	5.53	100%	0.1%
Bulbs	8.90 (2)	8.90	100%	0.2%
Flowers	12.14 (3)	12.14	100%	0.4%
Broccoli	162.00 (1)	162.00	100%	5.0%
Carrots	556.65 (7)	556.65	100%	17.2%
Leeks	14.97 (2)	14.97	100%	0.46%
Onions	233.10 (11)	233.10	100%	7.0%
Parsnips	517.61 (3)	517.61	100%	16.0%
Sugar beet	3433.00 (44)	0		
Beans	383.47 (7)	0		
Peas	1394.86 (14)	0		
Spring barley	1581.95 (16)	0		
Winter barley	2557.86 (25)	0		
Spring wheat	40.47 (2)	0		
Winter wheat	7881.44 (45)	0		
Linseed	966.66 (18)	0		
Oats	44.11 (4)	0		
OSR	1671.91 (14)	0		
Forage maize	84.98 (2)	84.98	100%	2.6%
Grass lays	1033.46 (15)	0		
Permanent pasture	1690.86 (14)	0		
Total	25903.74	3224.53	12.43%	100%

Table 3.12: Crop allocation (hectares)

Surprisingly, none of the farms in the sample irrigate sugar beet, which totals 3433.0 hectares and is grown by 44 farmers. Nationally, sugar beet makes up 9.7% of the total irrigated area in reported 1993 MAFF statistics, and 16.5% of the total irrigated area in Rees *et al's* study in 1993. The non-irrigation of this crop marks a significant change, and a number of factors have contributed to this. Firstly, and perhaps most importantly, the drought experience of 1989-92 forced farmers to re-evaluate their use of irrigation and reserve water, traditionally used on sugar beet for other high value crops. Secondly, in

the Lark and Thet-Little Ouse catchments the spread of the Risamania¹¹ disease and the possible linkage with irrigation, has critically influenced farmers and encouraged them to stop irrigation of the crop in order to ensure against the incidence of the disease. Thus, specific local problems in combination with water restrictions have led to a significant reduction in the area of sugar beet irrigated in the three catchments.

The marketing of irrigated produce varies, depending on the actual crop. The flower and plant producers either sell directly through the wholesale markets in Birmingham and London or through local market traders; while the fruit producers sell primarily through co-ops, although a small percentage is marketed through pick your own and farm shop enterprises. These producers are not involved in complex marketing relationships with the down-stream food network, and are wholly reliant on the free market, with no forward contracts or price guarantees. In contrast, the producers of potatoes and other vegetables, a total of 38 farms, are involved in complex and multi-various inter-relationships with the downstream food network, incorporating forward contract and free market production.

3.3.3 Phase two:- survey of actors in the irrigated production network.

Phase one interviews identified the network of social relations, specifically related to irrigated production within which the farm families were embedded. These interviews expose the way in which agents from off the farm directly and indirectly regulate on-farm irrigation decision making. The second phase of empirical work primarily concentrates on building up a picture of the processes of interaction between the State, market and social forces of regulation, within which farmers are embedded. Focusing primarily on the perspective of key actors from these spheres of regulation, the analysis aims to understand the mechanisms through which they directly and indirectly regulate on-farm production decision making, and gain an understanding of the relations of power which link

¹¹ A viral disease which primarily affects sugar beet. Once diagnosed, the farmer is prevented from growing sugar beet and other root crops for up to three years.

actors in a complex irrigated production network. Interviews are focused at two levels. Firstly, key actors in the local network of social relations are pinpointed for interview, as these actors directly influence on-farm irrigation decision making through direct face to face contact, and include local NFU and CLA representatives, as well as representatives from local produce marketing companies, irrigation equipment manufacturers and irrigation advice bureaux. These actors are linked into the networks of regional and national actors and so the second level of analysis focuses on regional NFU and CLA representatives as well as regional and national processing and marketing outlets for irrigated produce, irrigation equipment manufacturers and irrigation advice bureaux.

The survey had three primary aims:

- (i) to understand the way in which external agents enrol and control farmers in a network of social relations. How do they directly and indirectly control the production and consumption decision making of not only farmers but other agents in the food network?
- (ii) to explore the dynamic process of interaction with farmers. What strategies are developed by these agents to directly and indirectly regulate on-farm irrigated production?
- (iii) to examine these actors' knowledge and perception of water and the water environment. What is their understanding of the problems posed both for on-farm production and the water environment by unreliability of water supply?

The sampling strategy for this phase of work was not tightly structured and relied on the identification, by farmers in phase one, of key agents in the network of social relations who directly and indirectly influence on-farm irrigated production. Prior to the commencement of the empirical work it was assumed that irrigation advisers, irrigation manufacturers and marketing outlets for irrigated produce would play a significant role. In reality however, the picture was somewhat different, with limited contact between farmers, irrigation advisers and irrigation equipment manufacturers¹². Nevertheless, representatives from the food processing and packing industries proved critical, directly and indirectly regulating on-farm irrigated production through the specification of strict produce

¹² This in part reflects the low level of technological innovation in irrigation equipment manufacture in the UK, with the hose reel irrigator predominating on farms.

quality criteria for potatoes and root vegetables, the predominant irrigated crops in the farm sample. Twenty three companies were identified as the principal marketing outlet for irrigated produce (see Table 3.13 Part A), with a cross section of crisp manufacturers, potato merchants and frozen vegetable manufacturers. The sample frame does not claim to be representative of the whole UK potato and root vegetable market, but instead provides a window on, or snap shot of, the way in which regional, national and international food processors and marketing companies interact with not only other companies in the network but critically farmers at the local level.

Once again focused interviews were considered the most appropriate research tool, enabling detailed exploration of a limited number of issues. The interview schedules for companies identified in the irrigated production network cover seven key topic headings, with the emphasis varying depending on the nature of the company and its relationship with farmers at the local level. Topic headings covered the structure of the company; produce quality criteria; contract production; land rental; research and development; water resource management issues, and finally future options. All interviews were taped, and immediate full verbatim transcription ensured that the line of questioning was constantly under review so additional issues could be pursued in subsequent interviews if necessary.

	PART A: Sample frame	PART B: Completed interviews
Potato crisp companies	3	3
Potato chip companies	2	2
Potato merchants	5	-
Potato packhouse	5	5
Vegetable processor	4	-
Vegetable packhouse	4	3
Supermarket	2	2
Sub Total	25	15
Local NFU and CLA	6	5
Regional NFU and CLA	2	2
Farmer Groups	8	8
Environmental Groups	5	2
TOTAL	46	32

Table 3.13: Phase two sample frame and completed interviews.

The point of contact in the processing and marketing companies were individuals identified by the farmers, and in all cases they were based in either the agronomy or raw material procurement departments. Initially it was planned to conduct parallel sets of interviews with these individuals as well as with personnel in the product development and marketing departments. These departments were considered critical to the development of new products, as they were perceived as the key agents setting the product quality criteria which the agronomy and raw material procurement personnel then worked to. However, this path of investigation was closed as the agronomy and raw material procurement personnel refused to provide contact names in the other departments. Nevertheless, the interviewees were fully aware of the key requirements which the product development and marketing personnel demanded and provided insight into the dynamic interaction between the two departments.

In all, fifteen interviews were completed (see Table 3.13, Part B). Of these, ten were concerned solely with potato processing and marketing and included the dominant crisp and chip manufacturers in the UK and European markets. However, gaining access to the potato merchant sector proved difficult. None of the identified companies agreed to be interviewed, claiming constraints of time or no interest in the subject area. Nevertheless, interviews with the potato co-ops and commercial pack houses identified the key supermarket personnel responsible for the procurement of potatoes. A further two interviews were therefore conducted with supermarket personnel, thus tracking the potato from the farmers' field to the supermarket shelf. Three root vegetable pack houses agreed to be interviewed, reflecting the dominance in the Suffolk and Norfolk study areas of just four companies. Financial and time constraints influenced the decision not to contact the frozen vegetable manufacturers who were both located in Scotland. Thus the root vegetable network concentrates solely on the fresh market.

Phase one interviews identified the role and significance of NFU and CLA representatives in negotiations and representations with the NRA over access to and use of irrigation water. Local representatives from the NFU and CLA were easily identified for each catchment area, with six

individuals identified at the local level (see table 3.13 Part A). Nevertheless, in two research areas these representatives were by-passed in negotiations with the NRA, with the formation during the 1989-92 drought of farmer water groups. The breakdown of this traditional pathway of farmer negotiation was considered significant and thus an additional eight individuals from the water groups were pinpointed for interview.

In total five interviews were completed with local representatives from the NFU and CLA, which were supplemented by two further interviews with regional NFU representatives who held specific responsibility for spray irrigation issues. Interviews were also successfully completed with five representatives from the Lark Valley Abstractors group and three representatives from the Peddars way group in the Thet-Little Ouse catchment (see table 3.13 Part B). In order to contextualise the nature of the conflict in these two catchments during the 1989-92 drought, interviews with local environmental groups in the Lark and Thet-Little Ouse were considered important. Despite contacting local Friends of the Earth, Council for the Protection of Rural England and Royal Society for the Protection of Birds groups, no representatives were willing to be interviewed. Thus representatives from the Norfolk - Suffolk Wildlife Trust and the Brecks Countryside project were interviewed reflecting their importance in setting the local agenda on water abstraction and pollution issues.

3.4 The analysis and presentation of data

The analysis of the rich and detailed information which emerged from the empirical work posed a number of complex questions which focused on both practical and methodological issues. The sample size is not large enough to support detailed statistical analysis of sub-groups of the sample, and thus no attempt will be made to establish causal relationships between farmer types and irrigation use. Instead, the analysis concentrates on identifying the key characteristics among the sample in relation to farmer knowledge, use and management of irrigation water and the water environment. Initially, the primary focus of concern are the practicalities of managing and organising the different data sources. The interview transcripts themselves combine quantitative and qualitative data which are supplemented by

NRA statistics on licensed abstraction in the three catchments; MAFF parish data on agriculture in the three areas; as well as company reports, statistics and fact sheets. This morass of detailed information requires an organisational framework to ensure both the qualitative and quantitative sources complement and enrich the analysis.

The first step in organising the farm survey transcripts focus specifically on the quantitative data, which cover the nature of the farm business; water sources; irrigation equipment and investment levels. This information is recorded on individual summary cards and then transferred to a spreadsheet package (Lotus 123). This provides summary statistics on the nature of the farm sample and enables the generation of gross margin values and opportunity cost analysis of expenditure on water storage and irrigation equipment (see Appendix B for full details of methods employed). These figures provide a crude measure of the value in use of irrigation water and an indication of the willingness of farmers to pay for reliability of abstraction supply. Nevertheless, quantitative data form only a fifth of the farm survey transcripts and the management and analysis of the vast bulk of qualitative material requires a more imaginative system of organisation.

The analysis of qualitative data proves much more problematic than quantitative data, with no standardised methods and procedures of analysis, let alone clear guidelines on linking qualitative and quantitative data (Mason 1994). Two objectives shaped the development of the qualitative analysis. Firstly, the data must be easily accessible and manipulable to prevent time consuming sorting and resorting of transcripts. Secondly, the analysis must not get lost in the minutiae of farm management practices and must be firmly linked to and generate theoretical concepts and questions. Full verbatim transcription of all interviews were placed on the word processor, ensuring flexibility and easy manipulation of the text through the cut and paste function.

The literature on qualitative analysis emphasises the importance of developing descriptive and analytical categories to organise and classify the information (Mason 1994; Strauss 1987). This

necessitates searching through the transcripts for themes in order to develop categories which can then be used to index or code the data. Each paragraph of the transcript is then coded and placed in the appropriate computer file or filing cabinet folder. Numerous studies have documented how labour intensive and tedious this procedure is, often generating a mass of files and sub files (Porter 1994) plotting the key relationships emerging from the data.

Applying this approach to the farm survey transcripts, the analysis focuses firstly on the identification of key themes and relationships emerging under each of the ten topic headings. In all, twenty transcripts are initially categorised and the codes evaluated. On the basis of this, a code book recording all variables under each question is developed and this is then applied across all 62 farms. The next stage tests the nature of the relationship between categories, for example what form of irrigation application advice did farmers receive, was this related in any way to the farm size, marketing outlet or reliability of abstraction supply? Generating answers to this type of questioning can be time consuming, but is essential in identifying the key themes and theoretical questions for analysis. In consequence, descriptive categories under each of the ten transcript topic headings are given numerical codes and inputted onto the Lotus 123 spread sheet file holding the farm survey quantitative data. This enables the transfer of the file for use on the DBASE STATS package which apart from generating standard statistics also calculates two and three way cross-tabulations. Thus the data can easily be grouped and re-grouped, identifying the key areas of conflict and variation in the data. This provides a wholly descriptive account of the farm sample and identifies a series of theoretical questions which provide the starting point for further analysis of the transcripts.

This second stage of the analysis concentrates on the generation of conceptual categories and the identification of cross sectional themes. Five key questions are the starting point for analysis and concentrate on:

- (1) the externalisation of irrigation decision making;
- (2) contract farming and the redefinition of the land-water relationship;
- (3) changing nature of marketing relationships;
- (4) changing knowledge and perception of water, water rights and drought;
- (5) corporatism, negotiation and representation over access to and use of reliable supplies of irrigation water.

Using the cut and paste function on the word processor, relevant sections from each transcript are brought together in one file, clearly labelling the excerpts home address. This enables detailed exploration of conflict and variation in the data, while allowing easy access to the original transcript and summary card to contextualise the information. This is vital as it is wrong to assume all responses are equally valid and relevant. The fact that individual responses are influenced by a number of factors specifically related to that situation - such as the location of interview, the style of interviewing, who made the response and how they interpreted the question - must be considered in the analysis of the answer. This stage of the analysis concentrated on the detailed exploration of conflict and variation in the data and drew together a number of cross sectional themes and categorisations. Central to this are the concepts of risk and uncertainty, which emerge as key concepts in the analysis.

The results from the analysis of the farm survey are presented in Chapter Six, where a number of different presentational forms are mixed together. Tables and basic statistics on particular dimensions of the farm sample are used throughout the text, and case studies are also developed to provide insight into the dynamics of on-farm irrigation decision making, focusing particularly on the influence of actors from the irrigation production network. These case studies are chosen to represent the range of strategies found in the sample as a whole, and are exemplars of the dynamics influencing farm irrigation development. Detailing these as case studies enables examination of the combination of factors which influence farmer behaviour and traces the influence of State, market and social forces of regulation at the farm level. The other style of presentation is direct quotes from the farmer interviews,

which are used throughout the text to highlight particular points in the argument; however false names are used in order to protect the anonymity of the respondent.

Analysis of the interview transcripts from phase two adopts the same key principles. Nevertheless, the fact that interviews range across a number of distinctively different actors means the use of the computer spread sheet and statistics package are limited, as the sample size is too small to provide statistically significant results. This is not considered a problem, as the data provide key insights into how particular actors come together in particular places, and interact with and regulate, farmers' use and management of irrigation at the local level. Once again the key themes are identified in the transcripts and are used to build up case studies. Plotting the key linkages which tie potato and root vegetable processing and marketing companies into networks provides insight into the dynamics of network enrolment and control at a distance. The construction of flow diagrams establishes the form and function of these inter-firm relationships and ultimately with farmers.

Once again quotes from the transcripts are used throughout the text and company names are changed to ensure anonymity. Analysis of the irrigation production network is presented in two chapters. Chapter Five focuses on the network of market relations concerned with irrigated potatoes and root vegetables. Case studies are used to identify the form and function of companies relationships with one another and the implications this has for on-farm irrigation management practices. Analysis of the social forces of regulation is presented in Chapter Six, where once again case studies are used to explore the dynamic process of farmer negotiation and representation over access to and use of reliable supplies of irrigation water.

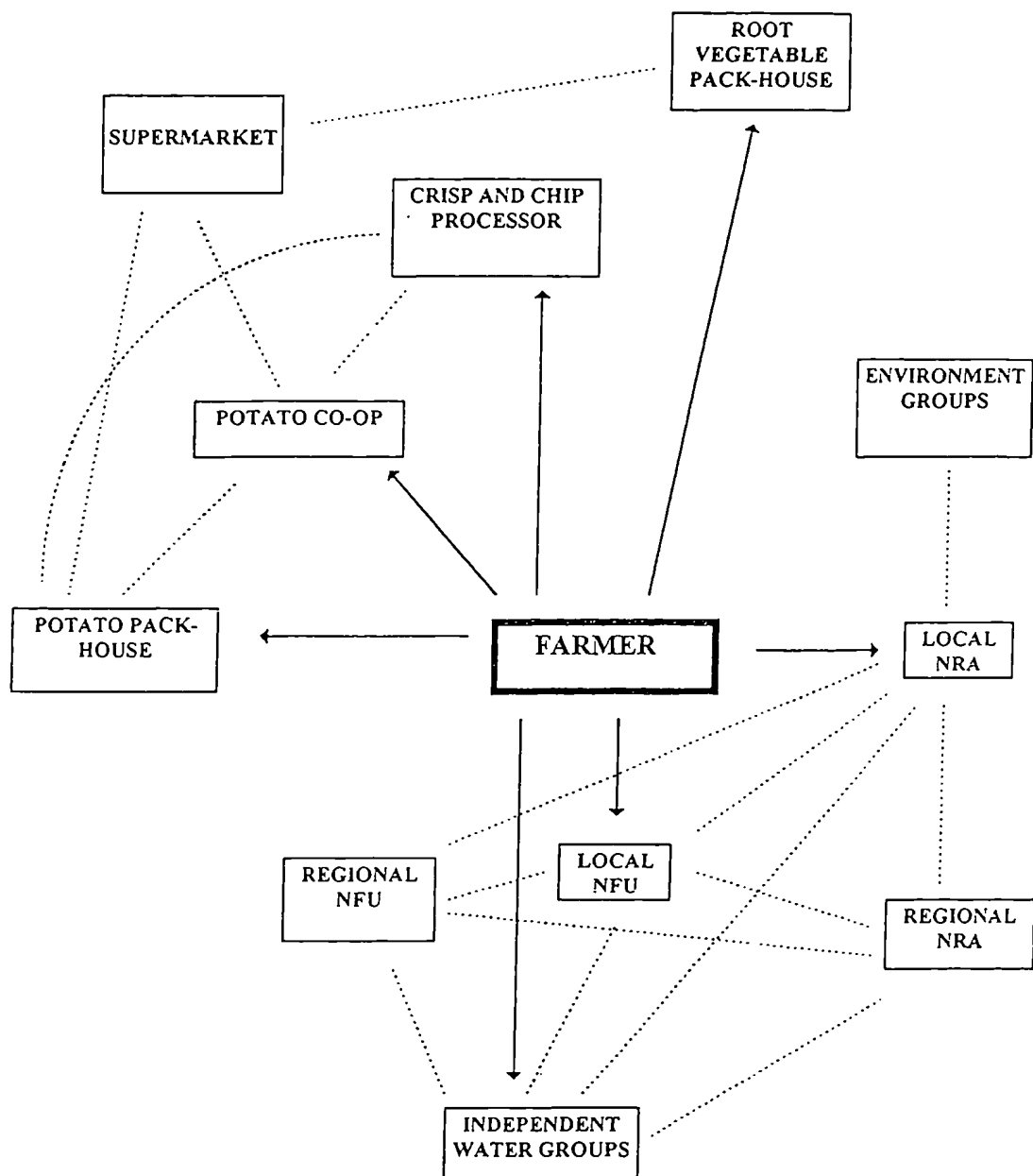


Figure 3.11: The network of social relations traced in the empirical analysis of the agriculture-water interface

3.5: Conclusion.

The application of the interface-network methodology to analysis of the agriculture-water interface exposes the network of social relations within which farmers at the local level are embedded. The complex and dynamic processes of interaction were revealed through the empirical strategy, which tracked farmers' inter-relationship with the NRA; NFU, CLA and produce marketing outlets to gauge the power and influence of these State, market and social forces of regulation over irrigation decision making. Figure 3.10 documents the form and function of these inter-relationships, and exposes the pathway of inter-linkages followed in the interviews. These inter-relationships are not simple or linear as the off-farm firms, state agencies and farmer representative groups are themselves incorporated into intricate inter-firm or inter-agency relationships. Through tracking the form and function of these inter-relationships, the analysis is able to build up a picture of the relations of power and dependence which critically shape interaction with farmers at the local level. In fact it is possible to distinguish three distinctive networks related to the NRA; NFU and produce marketing outlets which intersect at the agriculture-water interface. As figure 3.10 reveals there is only limited interaction between the downstream food network, NRA and farmer representative groups, while there is close contact between the NRA and farmer representative groups as they negotiate over access to, and use of, reliable supplies of irrigation water. Thus farmers, who are the focal point of these disparate networks, are forced to negotiate on three different levels and the analysis in the succeeding chapters will explore the actual nature of these inter-relationships and the implications for the use and management of irrigation water and the water environment.

CHAPTER FOUR

STATE INTERVENTION AT THE AGRICULTURE-WATER INTERFACE: THE INSTITUTIONAL CONTEXT

The dual processes of regulatory restructuring and de/reregulation have played a central role reshaping the form and function of state intervention throughout the 1980s and 1990s in both the water and agricultural sectors. Chapter One sketched out a broad outline of these dynamic processes of change, focusing in particular on the implications of regulatory restructuring and dissonance for environmental policy and the quest for sustainable development. This chapter will further develop these central arguments by concentrating on the detailed analysis of the political, institutional and administrative factors shaping the design and implementation of State policy at the agriculture-water interface. In addressing these issues, this chapter will draw on the postulates set out in Chapter Two, relating specifically to the state failure thesis and political science critique of the environmental policy process. These postulates contend that inappropriate state intervention perpetuates the dynamic displacement of environmental problems from one media, time or place to another (Janicke 1990; Andersen 1994), and that asymmetrical bargaining power; the legacy of the past system of regulation and administrative constraints critically distort all stages of the environmental policy process (O’Riordan 1976; Weale 1992; Rees 1990; Majone 1989; Downs 1967).

In order to explore the relevance and applicability of these arguments, the chapter is divided into three sections. The first section will concentrate on the detailed scrutiny of the institutional framework governing the allocation and regulation of water in the UK. This will examine the past and present role of vested interests in shaping the direction of water abstraction policy and the legislative and administrative constraints within which the water regulators operate. The implications of these processes for the allocation and regulation of water for use as spray irrigation and the water environment will be clearly distinguished. The second section will then move on to

examine the key forces shaping the future direction of water policy. The analysis will examine whether inappropriate state intervention in fact undermines integration of the environment into policy, by charting the shift in emphasis away from supply to demand management policies. This realignment of policy marks an important turning point, and the analysis in the third section will explore the specific implications of these policy measures for spray irrigation use. The analysis will set out how the principles of demand management translate into policy, and the critical barriers which, in reality, will undermine the efficiency and efficacy of these policy initiatives in the agricultural sector.

4.1: The organisational framework governing water regulation in the UK.

The development of a discrete institutional or legislative framework which concentrates solely on the allocation and regulation of water for use as spray irrigation has, to date, failed to emerge in the UK. In fact the reality is far more complex, as the regulation of spray irrigation use is inextricably intertwined with the other users and uses of water. It is vital therefore, to examine this wider context, to explore how the legislative and institutional constraints within which the regulators operate, influence the allocation and regulation of irrigation water. The analysis will concentrate on the detailed examination of the key players involved in the regulation of water use, namely the National Rivers Authority (NRA) latterly the Environment Agency, and the Office of Water Services (OFWAT), and will identify the financial, legal and administrative constraints which critically circumscribe their ability to effectively manage water supply and demand in the UK.

In the aftermath of the privatisation of the Water Companies in 1989, the organisational framework governing the regulation of water altered dramatically with the creation of the National Rivers Authority (NRA) and the Director General of Water Services (OFWAT). These organisations in combination with the Department of the Environment have core responsibility for the regulation of water. The EU also exerts an increasingly powerful influence particularly through the Water Quality and Urban Waste Water Directives, which will be reinforced by the proposed Framework

Directive on Water Resources. The regulatory framework governing the water sector is complicated, and although the wide dispersal of regulatory powers, insures against the possibility of regulatory capture by vested interests, it could lead to competition between regulators and the possibility that the regulated play off one regulator against another.

The division of responsibilities between the core regulators were set out in the 1989 Water Act which was subsequently consolidated into the Water Industry Act 1991 and the Water Resources Act 1991. The Director General of OFWAT has primary responsibility for ensuring that:

- water and sewerage functions are properly carried out throughout England and Wales;
- undertakers are able (in particular, by securing reasonable returns on their capital) to finance the proper carrying out of these functions.

The NRA, in contrast, is an independent statutory body with responsibility for:

- river quality and the quality of inland and coastal waters;
- land drainage and flood control;
- management of water resources;
- fisheries;
- recreation and conservation;
- navigation;
- licensing of abstraction water;
- independently monitoring river quality and discharges from sewage treatment plants.

In 1996, the NRA merged with Her Majesty's Inspectorate of Pollution (HMIP), the waste regulation authorities and some functions of the DoE to form a new Environment Agency which is a non-departmental public body sponsored by the DoE which takes over responsibility for the core water management functions. These bodies are all under the overall responsibility of the Secretary of State for the Environment (and for Wales, the Welsh Office) who has ultimate responsibility for steering policy change.

4.1.1: The National Rivers Authority (NRA)¹.

The wide breadth of the NRAs responsibilities reflects the integrated or holistic approach which is central to the management and development of water resources in the UK. This approach demands that the quality and quantity of ground and surface waters are dealt with in an integrated manner.

Hence, with respect to its water resource management function the NRA aimed

“..to manage water resources in order to achieve the right balance between the needs of the environment and those of abstractors” (NRA 1995b p32)

In the discharge of this duty, the NRA had four main tools: abstraction licensing, abstraction charging, catchment planning and resource management agreements. There are however, a number of legal and administrative constraints associated with these management tools which have built up over time and significantly distort and undermine the design and implementation of water policy.

1. Abstraction Licences.

The 1963 Water Resources Act introduced the abstraction licensing scheme into the UK and effectively transferred the function of water allocation from common law to the River Authorities.

The licensing system was primarily designed to exert control over water usage, and anyone taking in excess of 5,000 litres of water a year, from ground or surface water sources, had to obtain a licence specifying the location, time period and maximum quantity and rate of abstraction.

Nevertheless, the framing of the original legislation created and perpetuated a number of legal, environmental, financial and administrative problems which undermine the ability of the NRA to effectively discharge its duty.

The 1963 Act established permanent or licences of right which were granted to anyone who claimed to have abstracted water during the previous 5 years. The licensed quantity of water was calculated on the basis of abstraction usage during this period and as the River Authorities had no means of

¹ Merged into the Environment Agency from 1 April 1996. During the period this research was conducted, it was known as the NRA.

knowing accurately what this quantity was, the licence entitlements were effectively established by the abstractors themselves (Rees 1978). Licences of right were allocated to water undertakers, farmers and industrialists with little consideration for the impact on the water environment. In consequence the sum total of water allocated in these licences was, in some cases, greater than the available flow in the surface or ground water resource, particularly in periods of drought. Thus, low river flow levels and dehydrated wetlands are a direct consequence of the historical development of the licensing system, as the authorities failed to recognise and integrate the needs of the environment into the licensing system. Abstraction by public water supply companies holding licences of right, have a particularly negative impact on the water environment given the size and rate of their abstraction. Nevertheless, as licences of right do not come up for renewal, the NRA was unable to introduce stricter controls on abstraction. Renewable licences, in contrast, came into operation from 1969 and are renewed every 5-10 years, thus the licensing authority is able to amend licences in order to introduce stricter controls, such as cessation levels.

The abstraction licence does not guarantee the supply of water, nor is it wholly reliable, as under drought conditions the licensing authority can impose restrictions. Spray irrigation licence holders are subject, under section 45 of the 1963 Water Resources Act and consolidated in section 73 of the 1991 Water Resources Act, to temporary restrictions on abstraction which deny abstraction altogether or reduce the amount taken. The licensing authorities can themselves introduce these controls without having to revert to Drought Orders issued by the Secretary of State for the Environment. In consequence spray irrigation licence holders are vulnerable, in less extreme conditions, to the imposition of controls. In contrast, controls on Water Company and industrial usage are subject to special drought orders, issued by the Secretary of State for the Environment. Under section 73 of the 1991 Water Resources Act, a Water Company can apply to the Secretary of State for a drought order which can authorise:

- further restrictions by a Water Company on non-essential uses of water such as garden watering with hose pipes or filling of swimming pools or ornamental ponds, in order to conserve supplies for more important uses;
- abstractions of more water from surface or ground water sources than would otherwise be allowed;
- temporary use of water sources from which abstraction has not been licensed; or
- reductions in the amount of water that would otherwise be released from a river to maintain river flows.

As the licensing authority, the NRA had an advisory role, while power to implement an order rests solely with the Secretary of State. Although the NRA, in practice, was consulted on the likely impact on water resources, the environment and other abstractors, there were no statutory provisions to consider the impact on the environment, nor balance the needs of the Water Company against the environmental damage resulting from further abstraction. The problems associated with this approach were starkly revealed in the drought of 1995, when Yorkshire Water applied for 30 drought orders over a six month period to control domestic and industrial consumption. In fact, Water Companies have reverted to drought orders in six out of the last eight years and their use is a standard measure to control demand. These measures however, were originally designed for use in exceptional periods and not for use as routine measures resorted to as a matter of course to control demand or increase supplies. In fact, under drought conditions, the NRA is unable to effectively protect the *in situ* water environment as they rarely advise against Drought Orders, given the third constraint within which they operate (see below).

The second critical constraint focuses on the power of the licensing authorities to revoke unused licences or to decrease the entitlement in situations where actual consumption is well below authorised levels. In reality, the NRA and its predecessor the RWA, rarely exercised this right as the licensing authority must pay financial compensation to the licensee for any loss of capital assets, land value, or income flow from the land caused by the withdrawal of water. The compensation payable to Water Companies subject to licence revocation would be very high, although these costs

could be recouped through an increase in abstraction licence payments. However, these costs would ultimately be passed onto the consumer through increased water prices and thus political realities have to date prevented the actual revocation of licences.

The third constraint within which the licensing authorities operate, is the statutory duty laid down in the 1963 Water Act, which stipulates that public water suppliers provide supplies to all their customers. This has been interpreted to mean constraints cannot be imposed on abstractions by water undertakings, and underpinned the NRA's relationship with the Water Companies. The NRA was required by the 1991 Water Resources Act to have particular regard to the statutory duties of the water supply companies. Thus, the NRA had to ensure the Water Companies could provide "adequate" quantities of water to their customers. Clearly, this had critically important implications for NRA licensing policy, as they must effectively grant all Water Company applications for new licences or drought orders regardless of the environmental impact.

2. Abstraction charging

The 1963 Water Resources Act also introduced the principle of payment for water and in April 1969 the regional charging schemes came into operation. This scheme firmly established the guiding principles of abstraction charging which underpinned the regional NRA charging schemes. Abstraction charges were calculated on the basis of the total quantity of licensed water and all abstractor groups, with the exception of spray irrigators, were charged an annual figure which varied in relation to the source, period and use of abstraction water. Spray irrigation licence holders are the exception to this general rule as it was considered inequitable to charge for the full licensed quantity if irrigators were subject to abstraction restrictions under section 45 of the 1963 Water Act. In consequence, most spray irrigators are charged on a two part tariff, whereby they pay for 50% of their licensed abstraction at the start of the season and remaining payment is dependent on their actual consumption in the season. Thus, spray irrigators normally only pay the full licensed quantity charge in years when their actual usage reaches the full entitlement.

£/ Megalitre	Anglian	Midlands	Southern
Summer, irri*	£22.54	£14.97	£16.91
Winter, irri*	£ 2.25	£ 1.50	£ 1.69
Industry*	£ 8.45	£ 5.61	£ 6.34
Water Company metered unit charge	£69.62	£62.90	£52.10

Table 4.1: Regional abstraction charges 1996-7 (£/ML).

* Calculated on the basis of unsupported sources, otherwise figures vary significantly.

The charges levied under the abstraction charging scheme are minimal and rarely have an impact on water using behaviour (Rees and Williams 1993). Under the NRA abstraction scheme industrialists in the Anglian region paid £8.45/ML, while farmers paid £22.54/ML for summer abstraction and £2.25/ML for winter abstraction into storage for use later in the year (see table 4.1). These charges were typically only 3% of the cost of purchasing the same volume of water from a Water Company (NRA 1995a). The NRA and its predecessor the Regional Water Authorities (RWA's) were prevented from increasing water charges to incentive levels by a number of legislative constraints. The primary constraint was the duty imposed on the NRA only to set charges to recover current expenditure on water resource activities. Thus, the NRA had a duty to set charges to meet the annual cost, approximately £70 million, of implementing its water resource functions. As the Department of the Environment (1992b) itself recognises the resulting abstraction charging schemes

“..do not bear any relationship to the full costs imposed by particular abstractions including the costs imposed on the environment” (p24).

Reforming these schemes in line with the principles of incentive charging would ultimately lead to an increase in water charges potentially far in excess of current levels, creating profits for the NRA (Rees *et al* 1993), which under current legislation is untenable. Nevertheless, as Rees *et al* (1993) document there is still scope for improving the price signal to abstractors within the confines of the

cost recovery constraint. These options, however, were not incorporated into the new charging scheme of 1993, because of an NRA Board decision to minimise the shift in incidence of charges between abstractor classes. Political acceptability played a critical role shaping this decision.

3. Resource management agreements

The division of assets and responsibilities between the NRA and the privatised Water Companies in 1989 posed a number of complicated problems. The Water Companies themselves own the supply reservoirs (existing and future) and all ground water source works. The NRA in contrast was responsible for the availability and quality of water resources, but did not own the means of transforming resources into effective supplies. Thus the NRA was forced to rely on the Water Companies to provide supplies to support agricultural and industrial abstraction, recreation, fisheries and wildlife protection, waste disposal and pollution dilution. In periods of crisis such as a drought or a major pollution incident there was potential for major conflicts of interests between these competing users and uses of water which could have prevented a rapid and effective response. To overcome these problems the Water Resources Act 1991 enables agreements to be made between the NRA and Water Companies concerning the operation of water resource schemes owned by Water Companies.

Resource Management Agreements signed in 1989, based on previous internal agreements in the RWA's, set out the conditions for regulatory releases and arrangements for dealing with crisis. Nevertheless, if the NRA wanted to improve resource deployment within the region, or obtain additional regulatory releases during drought periods, these agreements would have to be re-negotiated. This posed a conflict of interests as the NRA had a statutory duty to have particular regard to the statutory duties of the Water Companies and ensure they can supply 'adequate' quantities of water to customers. This effectively undermined the ability of the NRA to re-negotiate management agreements in order to fulfil their environmental protection objectives and the Water Companies, understandably, were unwilling to agree to changes in these agreements which would

increase costs. Although the NRA was able to invest on its own behalf in supply enhancement or river regulation schemes, it was constrained by the availability of investment capital. Most investments have to be funded out of the revenue gained from abstraction charges and given the cost recovery principle which governs the setting of charges, the NRA was generally unable to accumulate sufficient capital to embark on major new investment projects. Thus, to overcome these problems the NRA had undertaken joint projects with Water Companies to benefit other users, although it was impossible to envisage these projects getting off the ground unless they were in line with Water Company plans.

4. Catchment management planning

Catchment planning was a relatively new management tool developed by the NRA and focused on the holistic or integrated management of water. The early stages of development coincided with the establishment of the NRA and initial discussions focused on the value of catchment planning to the corporate unity of the new organisation (Newson 1991). Catchment planning evolved and should not be confused with river basin management. The approach recognises the inherent dynamism and inter-dependence which characterise the use of water, with land use planning in particular, having a direct impact on water. Thus, the central objective of the catchment planning process was the development of an overview of all the pressures on water in a defined area. The plans focus on the multiple uses and users of water and therefore consider water quality, water abstraction, fisheries, flood defence, navigation, recreation, *in-situ* flora and fauna and wetland sites. The implementation of objectives in one sector may conflict with those in another and, in consequence, the catchment plans attempt to balance these by adopting an integrated or cross-functional approach (NRA 1995f). The objectives of catchment planning are summarised by Chandler (1994) as:

- to provide a consistent framework within which the responsibilities of the NRA may be discharged;
- to resolve the conflicts between objectives of NRA functions, both where the Authority acts directly and where it regulates the activities of others;

- to assign priorities for the division of scarce resources between NRA functions within a defined catchment area;
- to influence those whose actions impinge on the functions of the NRA, but over whom it has no direct control;
- to provide an opportunity for those with an interest in the water environment to influence the evolution of NRA operational policy.

Catchment plans are based on surface and ground water systems with the boundaries derived primarily from topographical features. A plan may comprise a whole river system, a group of adjacent catchments or a sub-catchment of a larger system, and in every case will include the surface drainage and its associated groundwater. 200 catchments have been identified by the NRA for individual management plans (Chandler 1994). The plans were developed on the basis of current and potential uses of water and water related activities, and explored the range of factors which impact on them. The environmental dimension of each use is integrated in order to provide a vision of the “ideal” river, which is then compared to reality and feeds into the prescription of significant issues and corrective actions. A consultative management plan is then drawn up which describes the catchment and its uses, compares the current status against relevant UK and EU legislation, lists the significant issues and sets out the management options, identifying their advantages and disadvantages. The consultation exercise attempts to gain the views of all concerned with the water environment including Local Authorities, industry, Water Companies, farmers and their representative organisations, environmental groups and anglers, and culminated in the production of a final plan which outlined the areas of work and investment proposed by the NRA and others over a five year period.

In theory, catchment planning offers a clear way forward in identifying and resolving the conflicts which evolve between water management objectives. In reality, however, this is incredibly difficult to achieve and the management plans often resort to little more than listing the problems and possible solutions. In fairness, this reflects the poorly developed information base on key processes in some catchment areas, and thus partly explains the very limited extent to which the concepts of

environmental interdependence and integration are explored in the plans. A good example is the Ely-Ouse catchment management plan, which covers the conflict catchment study areas of the Lark and Thet- Little Ouse. The document concentrates solely on the description and identification of potential problems under each of the key headings of water quality, water abstraction, flood protection, fisheries, navigation, conservation and recreation. Little attention is paid to cross-functional issues. This is revealed in the example of the impact of increased spray irrigation which is assessed purely in terms of the impact of abstraction on river flow levels and the implications for pollution dilution processes and the maintenance of water quality standards. Nevertheless, abstraction for spray irrigation can also directly contribute to the problem of pollution itself, given the potential threat of increased run-off and leaching of nitrates, pesticides and herbicides following the application of irrigation water. This is a particularly important issue on the flat sand lands of the Thet-Little Ouse which overlies a major chalk aquifer, where the soil is classified in the high risk category for leaching (NRA 1992a) and reflects a significant problem which is not addressed in the plan.

A second example, which concerns both the Lark and Thet-Little Ouse sub-units concentrates on the linkage and interdependence between water and land management. Both units fall within the Breckland Environmentally Sensitive Area (ESA), and farmers are encouraged, through a voluntary scheme, to conserve or improve the landscape, wildlife habitats and historical features of the Breck heathland. The predominant soil types are light sand land which, with spray irrigation, produce high quality potatoes and root vegetables. As the NRA itself recognised, demand for water for irrigation in these areas is unlimited, and thus the critical question should focus on the implications of meeting this demand not only for the water environment, but for the landscape itself. By implication an increase in spray irrigation will increase the area under intensive production of potatoes and root vegetables. This has an important impact as more land is converted to intensive production thereby altering the landscape and its dependent flora and fauna. Nevertheless, these issues were not even alluded to in the management plan and underlines the very limited extent to which the

principles of integration and inter-dependence are incorporated into the catchment management process.

The failure of catchment management plans to fully integrate and follow through the full implications of the concepts of inter-dependence and integration, may partly be explained by institutional factors. NRA functions in relation to water quality, water abstraction, flood protection, fisheries, conservation, navigation and recreation are all largely separate divisions within the organisation and thus there is little cross over among the staff on a day to day basis. Consequently, there is limited cross-fertilisation of ideas and issues, as staff are largely confined to their specific policy patch. Secondly, the budgets for each of these areas are separate, and thus even if a project emerged which served a number of inter-related objectives there would undoubtedly be difficulties deciding which budget or budgets should actually fund the project.

Chapter Two postulated that the past system of regulation would play a key role shaping the design and implementation of environmental policy. The analysis of the institutional and legislative context within which the NRA operated underlines the importance of this, demonstrating how the legacy of the past critically distorted the NRA's powers to effectively promote the sustainable development of water resources. This is revealed in the area of water licensing and charging, where the NRA was tied to schemes introduced in the 1963 Water Resources Act. Government reforms were a vital prerequisite to ensure the NRA could effectively discharge its duty and ensure the protection of the environment. However, political factors and the unequal balance of power between the NRA, OFWAT and the Water Companies are, in reality, a critical barrier to change.

The duties and responsibilities of the new Environment Agency with respect to water resource management do not differ markedly from those of its predecessor the NRA. Although the concepts of sustainable development and integrated pollution control lie at the heart of the new agency, it is questionable whether the structural changes will, in reality, foster closer integration of the

environment into policy. In the case of water policy, the new agency operates under the same institutional constraints which afflicted both the Regional Water Authorities and NRA. The agency has not been granted new powers and thus operates within the same legislative framework, with the same staff and operating procedures under the guise of a new name. In fact, the addition of a new duty on the agency further blunts its power, as it must now

“..work with all relevant sectors of society, including regulated organisations, to develop approaches which deliver environmental requirements and goals without imposing excessive costs (in relation to benefits gained) on regulated organisations or society as a whole” (DoE 1995b p2).

This duty is interpreted as a new and explicit constraint on the powers of the Environment Agency to effectively protect the environment and promote sustainable development, as it is now forced to consider the costs and benefits of all its actions, including those incurred by Water Company customers. Hence, the ability of the Environment Agency to encourage Water Companies to set strict leakage reduction targets or further expand domestic metering is undermined. The new agency, long heralded as vital to the development of integrated environmental policies, in reality represents a missed opportunity. The Government has shied away from instigating the reforms which are so central to the sustainable development of water resources in the UK, and instead reverted to piecemeal reforms which do not upset the prevailing balance of power or interests.

4.1.2: Office of Water Services (OFWAT).

The power and influence of OFWAT is critical in determining the integration of the environment into policy and the quest for sustainable development. Leakage levels, company charging policy and capital investment programmes all come under the remit of OFWAT, and are the key to ensuring the effective and efficient regulation of increasingly limited water resources. Nevertheless, the actual power of OFWAT is in reality diluted, as the DoE retains specific powers on key issues, and OFWAT is relegated to little more than an advisory role. Thus, OFWAT is unable to set statutory leakage control targets, and can only encourage the Water Companies to instigate action. Water metering is also a critical issue, but OFWAT is only able to advise and not direct Water Company

policy. Unlike the other privatised utilities and utility regulators, OFWAT and the Water Companies were under no statutory requirement to encourage the efficient use of water, until the introduction of an amendment in the 1995 Environment Act. Prior to this it was in the interests of the Water Companies to encourage the use of water, rather than promoting conservation and OFWAT was unable to challenge this position. The introduction of a new conservation duty on both the DG of OFWAT and the Water Companies reverses this position and marks an important turning point in their relationship. The amendment ensures the DG can stop companies introducing tariffs, such as declining block tariffs, which encourage water use rather than the efficient use of water. The amendment will also enable the Water Companies themselves to undertake water saving services such as tap re-washing, supply pipe inspection and information campaigns on the wise use of water in the home.

In line with the postulates set out in the political science critique of environmental policy, the analysis identifies the critical role played by legislative constraints in undermining and distorting the design and implementation of environmental policy. OFWAT operates under a number of legal constraints, which circumvent its power and influence over the Water Companies. In effect the power and influence of OFWAT was effectively blunted when the organisation was first created, and reflects the political manoeuvrings of Conservative Government Ministers, as they attempted to ensure the successful flotation of the Water Companies on the stock exchange at privatisation. These political factors have played a key role shaping the extent of OFWAT control over the direction of Water Company policy, as they have effectively avoided tougher policies on water metering and leakage control which are vital to the promotion of sustainable water resource management.

4.1.3: Asymmetrical bargaining power.

Both the EA and OFWAT operate under a number of constraints which are, in part, a legacy of the past system of regulation, and in part a reflection of political manoeuvrings to ensure the successful

privatisation of the Water Companies. Given these constraints, the relationship and interaction between the EA and OFWAT is critically important to ensure policy initiatives do not result in unintended consequences and side effects. A co-ordinated approach between OFWAT and the EA is critical; however this is undermined by the encroachment of OFWAT onto EA spheres of influence, which constrain its powers to effectively protect the water environment.

The EA itself is unable to force Water Companies to invest capital to alleviate the environmental problems which result from over abstraction. Investment programmes are negotiated at the periodic review of Water Company Market Plans. These quadripartite discussions involve OFWAT, EA, DoE and the Water Companies and reflect the unequal balance of power. The DoE intervened at the outset of negotiations in the 1994 Periodic review to restrict the level of price rises, forcing the NRA and OFWAT to accept a balance between environmental objectives and price rises (DoE 1993a). Major expenditure was required to ensure compliance with the EU Urban Waste Water Directive, the NRA was allowed to demand only limited expenditure to alleviate the problem of low flow levels. The environmental consequences of this decision are reflected in the south-west region, where the NRA was only able to successfully secure investment to alleviate low flow levels in one catchment, despite recommending three schemes requiring immediate action (NRA 1995e). Investment to alleviate these problems must await the negotiations of the next periodic review, by which time the damage to the *in situ* water environment may be irreversible. These negotiations expose the realities of the complex trade offs calculated between the EA and OFWAT, as they both represent different interests which ultimately conflict.

The relationship between the EA and OFWAT is not the sole source of conflict and contradiction in the water sector. Powerful vested interests in the Water Companies and their representative groups, the Water Services Association (WSA) and Water Companies Association (WCA), critically influence the form and function of regulation. Key figures within the old Regional Water Authorities played a central role drawing up the new privatised system, and went on to chair many

of the newly private Water Companies, although few are left today. Consequently, the system of regulation is heavily biased towards the protection of Water Company interests, with the power of the NRA effectively undermined by the duty to have particular regard to the statutory duties of the Water Companies and ensure they can provide “adequate” quantities of water to their customers.

In comparison to other vested interests, represented by fishing, environmental, boating and recreational groups as well as industry and agriculture, the Water Companies have unequal power and influence over the development of policy by OFWAT, EA and ultimately the DoE. This is reflected in the metering debate, where some of the Water Companies have persistently argued against the introduction of meters, citing the increased costs to customers and questioning the assumption that metering will, in reality, reduce demand and thereby put off to some future date, investment in new supply sources (WSA 1996; WCA 1996). The Water Companies and their representative organisations have orchestrated their resources to undermine the strong arguments for metering articulated by environmental groups, the EA and OFWAT. Nevertheless, underpinning these arguments are the other critical costs which metering will impose on the Water Companies themselves, including significant labour and capital investment costs incurred through meter installation, meter reading and billing systems. Unsurprisingly, these arguments have proved highly influential and, combined with the important social lobbying of doctors and welfare groups, critically influenced the Secretary of State’s decision to allow the continued use of existing charging schemes after March 2000. Thus, the introduction of a comprehensive national metering policy has been distorted by the powerful vested interests of the Water Companies, despite the insistence of both the EA and OFWAT that metering is critical to the sustainable development of water resources.

The power and influence of other vested interests concerned with water issues is relatively minor as the interests of the Water Companies reign supreme. The EA, through the Regional Flood Defences Committee, Regional Fisheries Advisory Committee and Regional Rivers Advisory Committee,

ensures that representatives from the Local Authorities, agriculture, industry, environmental and angling groups have a direct line of communication with the EA over the direction of policy. Representatives from these groups are also included on the Catchment Management Panels which play a critical role in developing and reviewing individual catchment management plans. Despite the establishment of a structure of communication, the EA and its predecessor have had to overcome a level of complacency and ignorance of the significance of water issues on the part of interest groups specifically in agriculture and industry.

In the agricultural sector both the NFU and CLA have focused principally on the issue of land drainage, and in successive rounds of water industry reorganisation, have successfully lobbied against the transfer of land drainage responsibilities from MAFF to the DoE (Richardson *et al* 1978). In fact, agricultural and land owning interests have dominated the land drainage system, determining both the evolution of institutions and policies (Parker and Penning-Rowse 1980). Farming representatives predominated on the Regional Water Authority Land Drainage Committees and, at the local level, on the Internal Drainage Boards and have overseen massive capital investment in drainage facilities (Parker and Penning-Rowse 1980). In stark contrast, agricultural interests in the allocation of water resources for use as spray irrigation have been largely ignored by both the NFU and CLA.

Although the Natural Resources (Technical) Committee (1962) argued strongly in favour of giving equal weight to the supply of agricultural and industrial demands for water, neither the NFU nor CLA capitalised on this and it never became a reality. Despite the concession of a two part tariff in the 1963 Water Resources Act², regional and national NFU and CLA officials failed to recognise the importance of water abstraction policy to agriculture. This situation prevailed throughout the 1970's and 1980's and in consequence through the drought of 1988-92, there was no established

² This concession was agreed on the basis that spray irrigators are the only abstractor group subject to Section 45 Abstraction bans. Hence, charging for water which may not be available was judged inequitable (Porter 1978).

structure of communication between national NFU, CLA and NRA officials on water abstraction policy. At the regional level, irrigation issues were discussed at a general, annual meeting between NFU, CLA and NRA representatives which also covered land drainage, flood defences and water quality issues. In consequence, agricultural interests represented by the NFU and CLA have exerted little direct influence over the direction of water abstraction policy. Nevertheless, this has been counter-balanced by the presence of MAFF, who have indirectly represented agricultural interests. MAFF played a key role in the nomination and appointment of NRA and latterly EA board members at the national and regional levels and in the appointment of representatives to the Regional Flood Defence Committees. Thus, although not directly focused on water abstraction policy, agricultural interests have been represented.

The drought of 1988-92 proved a critical turning point in the relationships between the NRA and agricultural interest groups, as the imposition of compulsory abstraction bans on spray irrigation licence holders underlined the importance of access to, and use of, reliable supplies of irrigation water for farmers at the local level. The NFU and CLA have established closer contact with the NRA at the national and regional levels (see section 6.2 for greater details), and culminated in 1995 with a significant concession to agricultural interests in the Environment Act. The amendment relates to the Land Drainage Boards, which hitherto had no involvement in irrigation. This situation has now changed, so these boards can manage water levels to facilitate irrigation. These boards could potentially play a vital role in the management of water for spray irrigation, providing not only an important forum for discussion at the local level, but also providing a key management structure for the reallocation of water licences and collective investment projects in water storage facilities. Although agricultural representative groups have played a relatively minor role shaping the direction of water abstraction policy in the past, they are now reasserting their influence and playing a more prominent role in the debate over the direction of water resource management policy.

The political science critique of environmental policy in Chapter Two postulates that asymmetrical bargaining power critically undermines and distorts all stages of the environmental policy process (Rees 1990; O’Riordan 1976). This analysis confirms the central importance of these processes. The unequal balance of power and influence between competing institutions and interest groups critically shape the design and implementation of water policy, and undermines the protection of the environment. The analysis demonstrates how political objectives critically shaped the division of responsibilities and duties between the Water Companies, NRA and OFWAT and culminated in the Water Companies wielding unequal power and influence over the form and function of regulation. The powers of both the NRA and OFWAT were effectively blunted by the Conservative Government’s desire for the successful privatisation of the water industry. The analysis also reveals how vested interests, namely agriculture, industry and environmental groups, have played a relatively minor role in the past shaping the direction of water abstraction policy; nevertheless this is now beginning to change. The conflicts and contradictions which characterise water abstraction policy reflect the competition between these different groups and institutions as they attempt to shape and influence all stages of the policy process.

4.2: The future direction of policy: balancing water supply and demand.

The image of drying out rivers, dehydrated wetlands, fields of dying or withered agricultural crops and parched domestic lawns and gardens, are firmly associated in the UK with periods of low rainfall and drought. The origins of these periodic water crises are not however simply physical scarcity problems, although this is how they are represented in the press and TV. In reality, the problems are far more complex, as policy intervention has exacerbated the situation, reflecting both market and state failure problems.

Inappropriate state intervention has in fact created and perpetuated a number of environmental and economic problems in the UK water sector and is reflected most starkly in the introduction of the licensing system in the 1963 Water Resources Act. Although the system successfully established

the principles which define and allocate rights to water, it also succeeded in creating far more complex environmental problems. The allocation of licences to existing users failed to recognise the impact of this abstraction on river flow levels and the *in situ* environment, and culminated in the level of licensed abstraction, in some catchments, being in excess of the in-stream flow levels. Thus, the unintended consequences and side effects of the licensing system are seen today in the problems of low flow rivers, dehydrated wetlands and over abstraction.

The introduction of the water charging scheme reflects the problems of both market and state failure. The scheme, also introduced in the 1963 Water Resources Act, introduced the principle of payment for water abstraction into the UK. The scheme exhibits signs of market failure as the price signals do not incorporate all the costs, including the environmental costs, of water use. Thus, water users are not forced to internalise the full cost of their resource use, as prices are too low to impinge on their decision making. These pricing principles underpin the charging schemes used by the Environment Agency today. However, reform of these schemes is further complicated by the cost recovery constraint introduced in the 1963 Act, whereby price rises are limited to recovering the costs incurred through implementing the water resource management functions. In consequence, the Environment Agency is unable to set prices at incentive levels to promote efficiency and water conservation. These complex market and state failures have critically undermined and distorted integration of the environment into water policy, and play a key role shaping the future direction of policy.

Traditionally in the UK water sector, a “supply fix” approach has predominated, whereby shortfalls in supply are resolved through the construction of new water sources. This approach has unquestionably assumed all future demand projections should be met, and has resulted in the massive investment in new supply reservoirs. The problems associated with this approach are exemplified in Kielder Reservoir and Rutland Water, where the demand for water failed to materialise in the planned time frame, and consequently Kielder reservoir is still largely under-

utilised today. The supply fix philosophy exemplifies the key features of the technocratic approach to the environment identified by Janicke (1990), whereby shortfalls in water supply are simply reduced to a technical question of enhancing supply capacity. The philosophy is deeply ingrained in the water sector, reflecting the predominance of an engineering framework of analysis, which closes off from consideration alternative policy options (Hirschleifer *et al* 1960).

The supply fix approach fails to address the underlying causes of demand increases, and concentrates solely on the construction of new reservoirs which, although successful in resolving the short term problem, only succeeds in shifting the problem to another time period, when the margin between supply and demand eventually narrows. This approach is unsustainable over the long term from both an economic and environmental perspective. Firstly, the number of suitable new reservoir sites are limited, and there is likely to be increased opposition from environmental and amenity groups to the loss of landscape and wildlife habitat. Secondly, the early commitment of resources of land, labour and capital to meet the inflated demands of water users is untenable from an economic viewpoint. The economic theory of market failure states that if consumers are not faced by prices which fully reflect the marginal costs of providing them with goods and services, then their demands will be inflated. These inflated demands can only be met if other users or the taxpayer are prepared to subsidise consumption. Over the short term, where total demands are within the available capacity of the system, these subsidies are low. However, if investment takes place to expand capacity, then the subsidies become large and obvious.

The predominance of the supply fix philosophy encountered a number of critical problems in the mid- to late- 1970s which increasingly brought into question the basic assumptions of the approach. A combination of forces ensured greater attention was focused on avoiding premature capacity development and increasing the useable output from existing supply sources (see Rees and Williams 1993 for a full account). Nevertheless, it is important not to overemphasise the importance of these changes, as the supply fix culture is still deeply ingrained in the post- privatisation regime. This is

perhaps best exemplified by the publication of the NRA Water Resources Development Strategy in March 1992 (1992b). This document outlines in detail the range of alternative water supply sources in the UK and covers inter-regional transfers, re-use of effluents, desalination, a national water grid, water from Europe, and the transfer of water by ship. Alternative measures such as demand management, leakage control and metering are only briefly alluded to and as Kinnersley (1994) argues

“The determined presentation of exclusive supply side strategies in this NRA discussion document represented a recycling of old thinking that a body claiming to be a guardian of the water environment had no cause to be pleased with. It was ignoring the fact that, if public opinion is to be moved at all towards moderating household usage of water, making it sound as if plenty of water from elsewhere could readily be transferred to the areas of still growing consumption could hardly be helpful” (Kinnersley 1994, p102).

Publication of this document and the ensuing criticisms marked the beginning of the end for the supply fix approach, with movement towards greater emphasis of demand management policies. This is an important switch in emphasis by the regulators of the water industry and a combination of factors influenced the change. The most important of which, was the drought of 1988-92 which underlined the vulnerability of certain regions to low rainfall and the economic, social, and environmental consequences. The final year of the drought coincided with publication of a Government consultation paper “Using Water Wisely” (July 1992) which was a key text in establishing the debate on demand management in the UK water sector. In combination with the CPRE (1993) report “Water for Life” and the POST (1993) publication “Dealing with Drought” these documents recognised the importance of demand management techniques in reducing the demand for new water supplies. This debate culminated in August 1995 with the Government itself recognising the shift in emphasis in “Water Conservation: Government Action”, which explicitly states

“Until recently, the normal response in the UK to water shortages was to open up new resources by sinking new boreholes or building new reservoirs....However, all options now have to be assessed from an environmental viewpoint and only those deemed acceptable should proceed. The Government’s position is therefore that existing resources should be used to the fullest possible extent, taking into account economic and environmental considerations, before additional resources are developed” (DoE 1995a p1).

This marks an important sea change in the culture of regulation, with the DoE, NRA and OFWAT switching the emphasis of state water policy.

Despite the sudden interest by Government, the NRA and OFWAT in demand management, the principles have been firmly established in the UK literature since the early 1970's (see for example Rees 1973; 1976; Herrington 1973), and overseas these principles have been put into practice in Australia, the USA, Canada and Israel (see Tate 1989; Long 1990; Howe *et al* 1986; Postel 1992). Demand management measures in combination with water conservation address the combination of market and state failures which afflict the water sector. Policy attempts to reduce the consumption of existing water resources and shift the demand for new supplies, thereby putting off to some future date investment in new sources. A combination of economic incentives and direct command and control style regulatory tools can be used, and include:

- water bylaws, building regulations and ecolabels;
- land use planning guidelines and rules;
- leakage control and targets;
- planned direct water re-use;
- indirect waste water re-use;
- dual water supplies;
- water conservation advice and audits;
- in-house re-use;
- water metering;
- incentive charging for abstraction;
- tradable abstraction permits.

These regulatory tools are by no means mutually exclusive and a combination of measures will be necessary to shift the perception and valuation of water in order to encourage, in turn, a shift in behaviour towards the wise use of water.

A central plank of demand management policies are economic incentives which include pricing policies for abstraction water, tradable permits and permit auctions. These measures reflect the classic policy prescriptions of the neo-classical economic model which, in theory, attempt to resolve the problem of market failure by improving the economic signal to consumers. This ensures that available resources are allocated between competing users and uses in order to maximise the total welfare derived from the resource. Consequently, all water users should be faced by water prices which reflect the full marginal costs incurred in supplying them, including the environmental costs. Prices should be measured in opportunity cost terms and reflect not only revenue and capital expenditure but also losses imposed on other water users. The application of these pricing principles to water proves highly complex, as water is not one product, but several, with widely varying cost characteristics. Ideally, volume charges should vary with the time of use, the supply source, location of use within the catchment and the quantity and quality of resource relevant return flows. Nevertheless, in reality, pricing schemes which conform to the principles of marginal cost pricing prove too difficult and complex to implement (Rees *et al* 1993).

An alternative, based on damage avoidance costs, proves less complicated and is based on the politically acceptable precautionary principle. Rees and Williams (1993) identify the central features of a damage avoidance cost scheme, which calculates, once politically acceptable stream quality objectives and minimum flow levels have been established, the long run costs of storage provision and other flow and quality enhancement measures. This forms the basis for the damage avoidance cost, which is then applied to particular units of abstraction, which vary in relation to the season of abstraction, the loss-return ratio, the location of abstraction and return flows in the catchment.

Overseas evidence relates how water pricing schemes shift water using behaviour, leading to greater awareness of water conservation in the home, industry and agriculture (Postel 1992;

Herrington 1997; Winpenny 1994; Rees *et al* 1993). Nevertheless, these schemes do not lead to an immediate change, and it is only over time that full cost charges shift the perception and valuation of access to and use of water. In light of these problems, economists argue tradable permits and permit auctions prove more effective and efficient in reallocating water resources among competing users and uses. In theory, tradable permit schemes offer a number of advantages over pricing systems (see Rees *et al* 1993 for a full discussion), and are based on the assumption that if a market is created in environmental goods and services, trading would ensure available resources are allocated to those who valued them most highly. The application of this system in the water sector also overcomes the state failure problems associated with the legacy of the system of property rights. As noted in section 4.1.1, the licensing system introduced in the 1963 Water Resources Act, established licences of right for existing users of water which are inalienable. A proportion of these licences are now under- or un-utilised, but current legislation prevents the Environment Agency from revoking these licences without paying compensation, which is politically and economically unacceptable. In theory, trading overcomes these problems by ensuring no costs are imposed on existing abstractors, who are granted *de facto* property rights, which are potentially valuable.

In theory transferability of all, or part, of the licence shifts supplies from low to high valued uses and thus improves efficiency. Trading systems can also potentially improve the environment, particularly in catchments suffering over abstraction and low flow levels. The licensing authority, through controlling the total number of permits issued within a catchment, would be able to ensure abstraction did not exceed the capacity of the catchment or aquifer. In the case of existing over abstracted catchments, trading would either have to be preceded by licence revocation and an auction of available capacity, or each licence would have to be reduced by an appropriate percentage to get the tradable quantity down to capacity (Rees *et al* 1993).

Under current UK abstraction charging schemes and water legislation it is impossible to introduce these changes. Nevertheless, a shift in Government policy heralded in the Environment White

Paper: The Second Year Report (1992) established their commitment to incorporate economic incentive measures into the centre of UK environmental policy. The attractions of economic incentives to the Conservative Government were acknowledged by John Gummer, Secretary of State for the Environment, when he stated

“By using appropriate instruments, we can spare industry the strait jacket of detailed regulation and still deliver high environmental standards. Indeed economic instruments may enable us to secure a continuing improvement in environmental performance more readily and automatically than we could do by old fashioned ‘command and control’ prescriptions” (1993b, foreword)

Despite these verbal commitments and the reiteration of the Government’s plan to publish a discussion document on the role of economic incentives in the water sector (DoE 1995a; DoE and MAFF 1995; DoE 1996a), in practice the introduction of these measures is no nearer, with the Government missing an important opportunity to incorporate the reforms in the 1995 Environment Act.

The shift in emphasis to demand management policies marks an important change in the form and function of water policy. Addressing the combination of state and market failures which afflict the water sector, these policy measures should, in theory, ensure the closer integration of the environment into policy. Nevertheless, although the realignment of state policy is important, the battle is not yet over. The design and implementation of demand management policies will be the subject of intensive conflict, as powerful vested interests attempt to shape and influence the form and function of the policy measures. These processes could critically undermine and distort the integration of the environment into policy and lead to further unintended environmental consequences and side effects.

4.3: The application of demand management principles in the agricultural sector.

The debate on demand management in the UK has concentrated almost exclusively on domestic and industrial consumers (see NRA 1995a), with little consideration of how these principles would be translated and implemented in the agricultural sector. To date, conservation of water in agriculture has focused on the construction of on-farm water storage facilities and the management of water during extreme drought periods (see for example MAFF 1992, 1996). Nevertheless, the switch in emphasis to embrace the principles of demand management, has critical and far reaching implications for agricultural spray irrigators which has been recognised by the NFU in a series of policy documents and speeches (NFU 1996; Naish 1994; Smyth 1995). Drawing on overseas experience it is possible to identify a range of policies which in theory could be introduced to significantly shift the agricultural demand for irrigation water (see table 4.2).

Firstly, farmers can introduce a number of changes to farm management practices over the short term, which could conserve and make more efficient use of existing supplies of water.

Encouraging farmers themselves to critically evaluate the use of spray irrigation on crops is vital to ensure water is not used on crops, where the response rate is low or where the economic value is marginal. Thus irrigation of cereals and sugar beet should be questioned, and irrigation water reserved solely for high value crops, where the response rate in terms of yield and quality are good.

Secondly, greater attention should be paid to the particular crop variety actually used. Drought tolerant varieties or even scab resistant potato varieties can significantly reduce the demand for water through the season, and reduce the impact of drought and water stress. The third

- use of drought tolerant crop varieties;
- switch out of irrigation of low value crops;
- improve crop cultivation techniques to improve the soil moisture retentive capacity;
- use of irrigation scheduling systems;
- use of efficient application technology;
- direct reuse of treated effluent;
- recycling;
- economic incentives;
- construction of on-farm water storage.

Table 4.2: Demand management options in the agricultural sector.
(Postel 1992)

option concerns the use of alternative soil cultivation techniques, such as bed systems instead of ridges in potato production for example, which can critically improve both the moisture retentive capacity of the soil and reduce run off water. These measures, in combination, would make more efficient use of water which is actually applied.

The fourth critically important factor influencing agricultural demand for water is the irrigation equipment itself. Hose reel irrigators predominate on UK farms and are a highly inefficient way of applying water, as water is lost not only through wind blow but the rate of application is also highly variable (Bailey 1990; 1993). Trickle or centre pivot systems are far more efficient, applying water directly to the root system, with trickle systems reducing consumption of water by 25-30% compared to hose reels (Bennington 1994). Nevertheless, these systems are highly capital intensive, although recent developments in irrigation tape technology³ may prove more economic

³ Irrigation tape is made up of two pipes one within the other. One acts as the main supply while the second smaller pipe feeds water out through slits spaced 20cm apart. The tape can be laid in a potato ridge a few inches above the potato seed when planted. The manufacturers claim that operating the system 1 hour a day is sufficient to apply 1 inch of water a week.

at £940/ha for renewable tape (Farmers Weekly 10.5.96). Technological innovation may lead to further developments in this area, improving the efficiency of water application. Current irrigation scheduling systems also play a vital role, as they focus on maintaining critical soil moisture deficit levels, to maximise crop growth and hence yield and quality. As Weatherhead *et al* (1994) acknowledge, the switch to irrigation scheduling systems may, in reality, actually increase the amount of water used. In consequence the fifth policy option focuses on encouraging manufacturers to develop alternative scheduling systems which maximise the efficiency of water applied, ensuring less water is applied but at the critical stages of crop growth.

Federal Republic of Germany

One of the longest operational uses of waste water for plant production is at Braunschweig, where around 44,500 m³ per day of waste water is used for an irrigation scheme which has been operating since 1954.

France

On the island of Porquerolles, waste water is used to irrigate citrus, apricot, peach and plum trees. Thus use of treated waste water represents 60% of the irrigation water demand.

Israel

It is estimated that 23% of the irrigation of cotton, citrus, field and fruit crops is supplied by marginal quality water.

Ukraine

Irrigation with partially treated sewage effluent has shown marked increases in soybean and maize yields and it has been calculated that waste water could provide 15-20% of all irrigation water requirements.

Table 4.3: Direct re-use of treated effluent - overseas evidence.

(Source: Postel 1992)

The sixth option, direct reuse of treated effluent, has been largely dismissed by the UK Government on the basis of possible health risks. Nevertheless, irrigation water does not need to be of potable quality and is recognised by the World Health Organisation, which established quality standards for irrigation water which limit the level of faecal coliform and parasitic worms, two of

the main disease carrying agents. Thus, as long as reuse water is only used on crops which are peeled, skinned, cooked or processed before being eaten there are minimal health risks. Direct reuse schemes have been developed for irrigation purposes in the USA, Australia, South Africa, Japan, Israel and Singapore (see table 4.3) and have the advantage of not only providing a supply source rich in nutrients which can reduce the use of fertilisers, but is also a reliable local supply.

The final option focuses on the role of economic incentives. The current abstraction charging scheme for spray irrigation provides few incentives for water economy, with water costing £22.54/ML for summer abstraction in the Anglian region or £2.25/ML for winter abstraction (see table 4.1). In consequence the actual price signal has limited impact on irrigation decision making as the cost of water itself represents only a small proportion of irrigation running costs. In fact, fuel and labour are the most significant cost elements (Weatherhead *et al* 1994), and can influence irrigation management significantly. The scheme does incorporate some incentive measures, primarily the differential between the cost of winter and summer abstraction (see table 4.1), in an attempt to encourage the construction of on-farm water storage facilities. Despite this, the current scheme does not encourage water conservation, as charges are based on a two part tariff, and therefore only a fraction of the cost is related to the actual volume of water used. Reform of the current abstraction tariff scheme in line with incentive charges based on damage avoidance costs, would ensure charges are related to the actual volume of water used. The weighting factors used in the scheme could vary depending on the source of supply (surface or ground water), point of abstraction (up or downstream) and period of abstraction (winter or summer). In consequence, the weighting accorded to winter abstraction could be set at zero, to encourage more effectively the construction of on-farm reservoirs (Rees *et al* 1993).

An alternative to economic incentive pricing is tradable permit systems, which offer a number of advantages in the reallocation of existing agricultural licences. The differential between licensed and actual abstraction is, in fact, quite significant in the agricultural sector (see tables 3.3 Parts A

and B) and in the three catchment study areas 37 licences were either untraceable or no longer used. This represents in total 581.456 tcma in the Lark; 692.612 tcma in the Thet-Little Ouse and 271.712 tcma in the Bain Witham (see table 4.4).

	Lark	Thet-Little Ouse	Bain-Witham	TOTAL
Untraceable licences	7	7	4	18
volume	548.294 tcma	398.24 tcma	60.927 tcma	
Un used licences	7	4	8	19
volume	33.162 tcma	297.372 tcma	210.785	
Total	581.456 tcma	692.612 tcma	271.712 tcma	37

Table 4.4 : Breakdown of the un-used and un-traceable licences in the three catchment study areas.

Undoubtedly there is significant potential to reallocate existing supplies of under- or un-used water to other uses and users. The introduction of tradable permit systems would be relatively simple in the agricultural sector, as long as trading is confined within specific geographical areas and involves only farmers. This ensures that all traders have broadly similar market power and prices are not distorted by the financial power of individual Water Companies (Rees *et al* 1993). The Environment Agency could control and regulate the number of licences available in the catchment, to protect other abstractors and the water environment. In the case of over-abstracted catchments, the Environment Agency could either buy up licences as they come onto the market, or revoke licences not used in the previous 5 years, reallocating the released water to ensure the protection of the *in situ* environment and river flow levels. The system could trade licences either permanently or on a yearly basis and therefore prior to the commencement of the growing season, farmers would evaluate their water needs on the basis of their rotation; farmers with a surplus would sell their entitlement; farmers with a deficit would buy water which would then be transferred via the river or drainage network for application on their own land. The organisation of the system would be relatively simple and cost effective, particularly in light of the recent amendment to the Land Drainage Act (1991) in the Environment Act 1995, which would enable the internal drainage boards to organise and administer the system at the local level.

These policy reforms should, in theory, lead to a sustainable pattern of water use in the agricultural sector. In reality however, the situation will prove far more complex as there are not only critical political and institutional barriers to change, but it is questionable whether these policies will in fact prove effective in changing the behaviour of farmers. Undoubtedly, the design and implementation of demand management policies will be subject to intensive political scrutiny and lobbying from a variety of vested interests. Farmers and their representative organisations are unlikely to passively accept changes which increase their costs. Consequently, it is possible to predict with some certainty that political bargaining processes will play a key role determining the actual form of demand management policies in the agricultural sector.

This approach to policy can also be criticised at a more fundamental level, as it is questionable how effective these demand management policies will prove in realigning the use and management of water at the farm level. The current debate, both in the UK and overseas, has progressed within very narrowly defined parameters reflecting a purely sectoral approach to water policy. Consequently policy makers from the EA, OFWAT and the DoE fail to take account of how other State, market and social forces of regulation influence both the use and management of irrigation water and response to demand management policies. As Chapter One argued, it is vital to adopt a wider inter-sectoral approach to policy, to avoid the unintended consequences and side effects which undermine and distort integration of the environment and economy. This is not happening in the design and implementation of demand management policies to control irrigation use. Policy makers fail to recognise how specific state policies developed by MAFF and the EU, and market forces of regulation emanating from the food network, critically undermine and distort their specific policy initiatives on the wise use of water. Nevertheless, it is inconceivable that farmers' response to tradable permit systems, for example, will develop in a vacuum completely divorced from their wider management objectives and strategies. The conflicting and contradictory policy signals emanating from the plethora of State, market and social forces of regulation will play a key role

shaping farmers' responses, and it is therefore vital that water policy makers recognise and address the multiple layers of regulation within which the target population are situated.

This is no simple task, as the agricultural sector has witnessed an intensive period of change, with a major shift in emphasis and power away from the producers of food (Marsden and Little 1990).

Farmers are now locked into an increasingly complex food system with input suppliers, food manufacturers, processors, retailers and wholesalers playing an increasingly important role alongside traditional MAFF, EU and GATT officials in regulating both the production and consumption of food. These non-farm parts of the food system have been dubbed the "new regulators of the food system" (Flynn and Marsden 1992), as they directly and indirectly penetrate on-farm production decision making to ensure reliability of supply, consistent quality and acceptable prices (Marsden and Wrigley 1994). In consequence, farmers have to balance the demands of their new masters, against those of the State regulators in MAFF and the EU who are grappling with the increasing financial costs of the agricultural price support system, while at the same time integrating environmental protection objectives more closely into agricultural policy. This poses a number of complicated questions for farmers as the signals emanating from the non-farm parts of the system may potentially conflict with, and undermine official EU and MAFF policy and vice versa. Hence, dissonance between agricultural policy objectives is increasing and poses greater risks and uncertainties for farm management and by implication the management and use of irrigation water.

Changes in the form and function of agricultural state intervention have variable implications for irrigated production. On the one hand irrigated produce falls largely outside of the CAP price support system and in consequence production is largely unaffected directly by the reforms introduced under MacSharry. However, these changes do have an indirect impact which should not be underestimated, as uncertainty over the direction of policy reforms contribute an important element of insecurity and uncertainty to on-farm production decision making. Consequently,

farmers may, for example, have increased the area under production of irrigated crops, thereby reducing their vulnerability to reductions in the price support system; they may also have reduced their level of capital gearing by cutting back on investment in major projects such as equipment or buildings, in order to reduce their vulnerability to price volatility.

Irrigated production is more directly affected by the new Government reforms of the Potato Marketing Board (PMB), as irrigation in the UK is largely concentrated on potatoes (Weatherhead *et al* 1994). Changes to the structure of the PMB and the removal of intervention and quotas pose significant risks and uncertainties for producers. Restructuring of not only the production of potatoes but also the marketing relationships with downstream food network may result. These changes will have important consequences for irrigation use. Small potato producers may move out of potato production and thereby no longer use their irrigation licences; in contrast, other large potato producers may intensify potato production, increasing the acreage and thereby increasing their demand for irrigation water. Reform of the PMB potentially has important unintended consequences for the use and management of water at the farm level and future demand for abstraction water.

The reforms to the form and function of state intervention in the agricultural sector throughout the 1980s and 1990s mark a significant shift to the post-productivist agriculture, where the protection of agriculture for agriculture's sake is no longer the guiding principle of policy formulation. Although not directly concerned with irrigation, the reforms introduced both by MAFF and the EU have a number of unintended consequences, which potentially influence the use and management of irrigation water, and distort the response of farmers to the policy signals emanating from the Environment Agency on demand management.

Running in parallel to the changes in the form and function of State regulation, the UK food network also plays a critical direct and indirect role shaping on-farm production decision making.

The power and influence of these forces of market regulation have increased throughout the 1980s and 1990s; companies both up and downstream of the farm have been able to penetrate on-farm decision making in order to control and manipulate production (Munton 1992; Marsden *et al* 1992; Hawkins 1991 and 1994; Ward 1994a+b). These firms could play a central role shaping both farmers use and management of irrigation water and response to demand management policies. Irrigation equipment manufacturers could critically shape the process of technology transfer, encouraging farmers through tailor made financial packages and after-sales technical back up to purchase specific types of irrigation equipment. Obviously, these processes could undermine the Environment Agency's message on demand management and the conservation of on-farm water, by promoting machinery which perpetuates the inefficient and wasteful use of water. Food manufacturers and processors could also play a critical, although less obvious, role shaping irrigation decision making through their specifications in relation to consistency of produce supply and quality. These divergent signals could have significant unintended consequences and side effects for the use and management of on-farm irrigation water, as they potentially contradict and conflict with the policy signals emanating from the Environment Agency.

Explicit identification of the wide number of state and market forces of regulation impinging on decision making at the farm level, underlines the potential sources of dissonance which will undermine and distort the power and efficacy of demand management policies in the agricultural sector. Environment Agency officials must consider how the combination of regulatory forces could be realigned to ensure they work in synergy rather than dissonance in order to promote the sustainable development of water resources. This critical task moves beyond simply the closer integration and co-ordination of Environment Agency and MAFF policies, which in itself is important, and must instead address the far more complex issue of ensuring synergy between market and state forces of regulation. Undoubtedly, this alternative approach will encounter political, institutional and administrative problems but these must be overcome to ensure the removal of a critical barrier which impedes the integration of the environment and economy.

4.4: Conclusion

This chapter has identified the combination of state and market failures which have critically influenced the form and function of regulation at the agriculture-water interface. Inappropriate state intervention has culminated in the problems associated with low flow levels, over abstracted catchments and dehydrated wetlands. The origins of these problems can be traced back to the system of licensing introduced in the 1963 Water Resources Act. The legacy of the reforms introduced in this Act constrain the effective and efficient regulation of water today, by impeding the introduction of demand management measures such as incentive charging and tradable permit schemes. The analysis also underlines how the institutional framework governing the regulation of water has been critically shaped by political bargaining processes. The Conservative Government ensured the successful flotation of the Water Companies on the stock exchange by designing a regulatory framework which did not impose undue price constraints or impede Water Company interests. Thus the division of responsibilities and duties between the NRA, OFWAT and Water Companies ensured the effective protection of Water Company interests. OFWAT is unable to impose compulsory leakage targets or water metering and can only advise Water Companies on the best way forward. Reliance on the voluntary principle ensures an incremental process of reform, as the Water Companies introduce policy changes in a piecemeal fashion. The power and influence of the NRA to protect and conserve the water environment and the interest of other users of water is also circumscribed by its relationship with the Water Companies. This is revealed in the duty imposed on the NRA to have due regard to the interests of Water Companies, and ensure they have “adequate” quantities of water for their customers. The unequal balance of power and influence between the official regulators and the Water Companies, and between the Water Companies and other interest groups, plays a critical role shaping the design and implementation of policy in the water sector.

Institutional and political constraints have critically influenced and distorted the policy process and contributed to the technocratic, piecemeal approach to water supply, where the construction of new water sources has been the automatic response to supply and demand imbalance. This policy approach, however, has only succeeded in shifting the problem to another time and place as it does not address the real problems underlying the imbalance between water supply and demand and the increasing conflict between the users and uses of water. The analysis reveals how the shift to demand management measures, combining economic incentives and direct command and control style regulations, redress these problems focusing on the combination of market and state failures which afflict the water sector. Nevertheless, there are still real problems associated with this approach which are revealed in the discussion of the role of demand management policies in the agricultural sector. The analysis demonstrates how the integration of the environment and market through demand management policies is undermined in the purely sectoral approach to policy which focuses solely on the water sector. In reality the EU, MAFF, DoE, supermarkets, input suppliers, food processors and manufacturers all play a central role shaping farmer decision making and consequently will critically influence the response or non-response to demand management initiatives. Resolving these problems is vital to ensure that the plethora of regulatory forces at the agriculture-water interface work in synergy rather than dissonance and thereby enable the effective integration of the environment and economy.

CHAPTER FIVE
THE FOOD NETWORK AND QUALITY: TRACING THE IMPACT OF MARKET
FORCES OF REGULATION ON IRRIGATION USE AND THE WATER
ENVIRONMENT

The power and influence of market forces of regulation potentially play a critical role shaping integration of the environment and economy. Chapter Four demonstrated how the international food network directly and indirectly controls and regulates on-farm production decision making, and highlights two critical questions which are central to this analysis. Firstly, how do off-farm firms directly and indirectly regulate and control the on-farm use and management of irrigation water? What are the implications for demand management policies and protection of the environment? This chapter, drawing on the focused interviews with firms involved in the marketing and processing of potatoes and root vegetables, will concentrate on the detailed exploration of these complex issues and will employ the postulates set out in the theory of the firm, political economy tradition, and literature on risk and uncertainty. These postulates will enable the analysis to examine the nature of the inter-firm linkages, exposing in particular the relations of power and dependence which shape interaction between firms, and between firms and farmers, identifying the critical barriers to change which will potentially undermine the efficiency and efficacy of state forces of regulation, in particular demand management policies.

In addressing these issues, the analysis will be presented in four sections. The first section will concentrate on establishing the key features of the national potato and root vegetable market, the primary irrigated crops in the UK, providing critical insight into the key actors involved in the different market sub-sectors and the changes which have occurred in the pattern of production across the UK. This establishes the broad national context within which the surveyed firms operate. The second section will move on from this and examine the potato and root vegetable

network, describing the form and function of the inter-relationships and inter-linkages between firms, and between firms and farmers. This analysis will explore the direct and indirect measures through which firms control each others behaviour, focusing in particular on the role of the supermarkets and the potato processing companies. These actors play a key role in the potato sector, and the analysis will explore the relations of power and dependence which underpin their interactions with subordinate firms and farmers. The key mechanism through which these companies exert indirect control over on-farm production is through the specification of strict produce quality criteria. The third section of this chapter will examine in detail the competing definitions of quality and the implications for the use and management of irrigation water at the farm level. The final section will draw together these various strands of analysis to critically assess the impact of these complex inter-relations on irrigation use and the water environment. The analysis will explore the role of off-farm firms in implementing demand management policies, highlighting the critical barriers to change.

5.1: The UK potato and root vegetable market: the national picture.

The potato market represents one of the most highly segmented sectors of the UK vegetable industry, with significant value added to the product after leaving the farm gate. On-farm production of potatoes has been subject to significant levels of uncertainty over the last five years, with the future of the PMB and the quota system under Government review. In addition, average prices have been extremely volatile (see table 5.1) with significant inter- and intra- seasonal variation, ranging from a low of £60.60/ton to a high of £173.10 in the 1994 season, while in 1995 prices ranged between £100/t to £260/t. These figures mask significant price variations with premiums attached to specific varieties and produce which conform to precise quality specifications. Morris (1993) suggests post-harvest prices range from £30/t for outgrades, through to £45-50/t for general ware, to £90-120/t for quality pre-pack standard. In the processed market, prices typically stand at £60-70/t. In combination with the high variable costs associated

	1991	1992	1993	1994	1995
Registered potato producers	14,254	13,667	13,493	12,356	11,625
Total area ('000 ha)	154.3	154.9	148.1	141.0	146.3
of which:					
early	51.0	52.1	52.4	51.9	55.0
main crop	103.3	102.8	95.7	89.0	91.3
Irrigation					
Area receiving irrigation	37%	39%	37%	47%	49%
Yield irrigated crop t/ha	46.1	52.3	49.7	51.1	50.4
Yield unirrigated crop t/ha	37.5	48.7	46.4	44.2	38.4
Total production ('000t)	5001	6239	5763	5231	4982
Average maincrop producer price (£/t)	78.2	85.7	56.6	79.5	156.86
Price range	62.9 - 115.3	75.2 - 111.5	48.6 - 72	60.6 - 173.1	100.6 - 260.9

Table 5.1: Potato production in England and Wales.

(Source: PMB 1996)

with production, on average £1500/hectare (Nix 1994), the farmer is subject to significant levels of economic risk and uncertainty. These factors have contributed to the decline in the national potato area, which dropped by 8,000 ha between 1991-95 and the number of registered producers fell by 2,629 (see table 5.1). Nevertheless, this has not translated into a marked decline in the level of total production, implying an intensification of the scale of production on the remaining farms (Bates *et al* 1996).

Although the pattern of production across the UK has remained relatively stable over time, there has been a movement towards use of light sand and chalk lands in Essex, Suffolk, Norfolk and

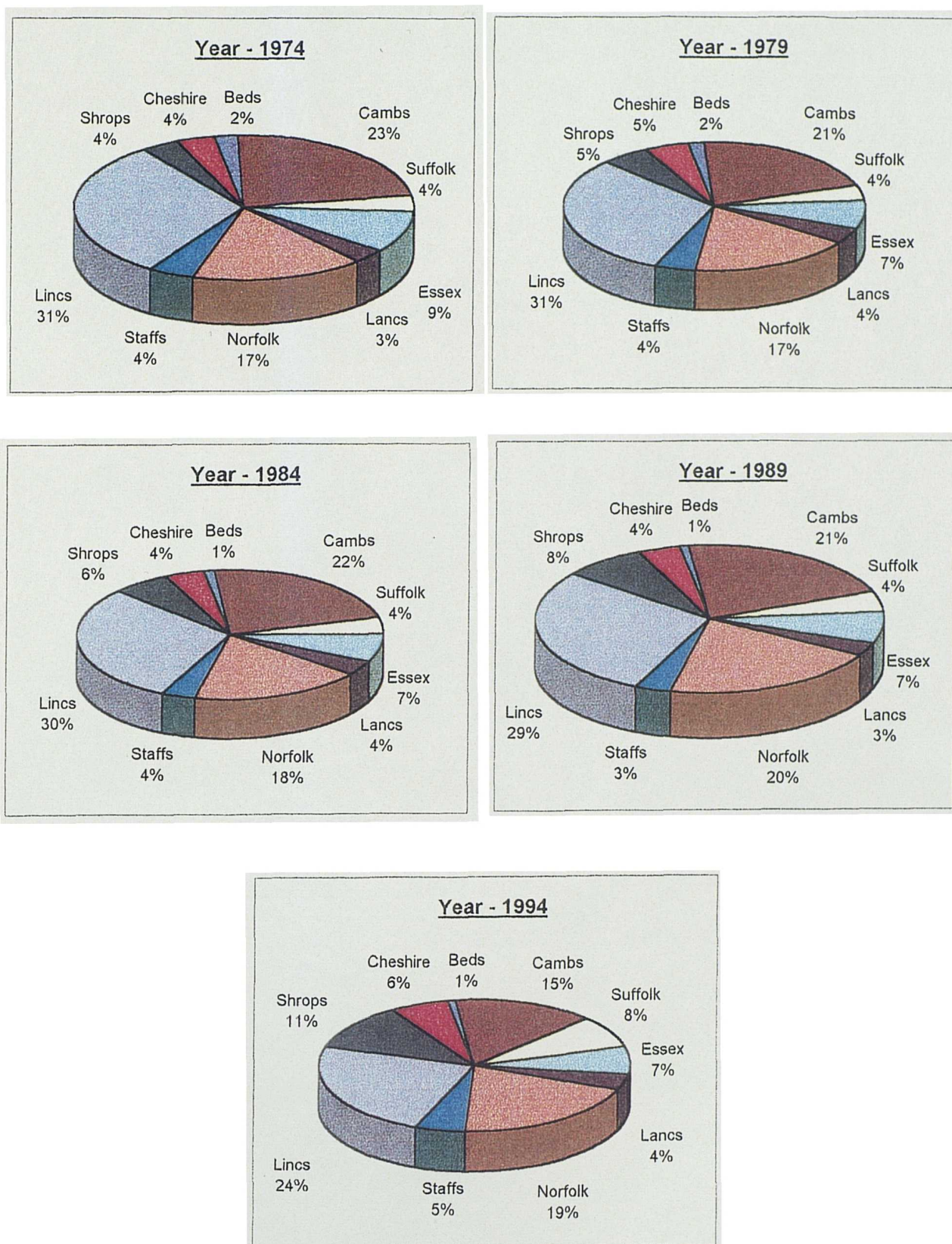


Figure 5.1 : The changing geographical pattern of potato production in the UK.
The proportion of the national potato area by county
 (Source : PMB various years)

Lincolnshire whereas production on the heavier soils in the fens of Lincolnshire, Lancashire, Cheshire and Cambridgeshire has remained relatively stable (see figure 5.1). As Morris (1993) recognises, this shift reflects changes in potato production methods which favour lighter, more drought prone soils. In fact the movement towards lighter soil types enables greater production flexibility, allowing access to potatoes throughout the season without the problems of water logging as well as avoiding significant eel worm problems which afflict the fen and silt lands. Despite these advantages, lighter soil types do not retain moisture and are more prone to drought; consequently potatoes are vulnerable to problems of common scab and irrigation is an increasingly vital element of production. The proportion of the potato crop receiving irrigation has increased markedly in the five eastern counties (see figure 5.2), with Essex experiencing a doubling in the area irrigated between 1982 and 1990 from 1100 ha to 2250.1 ha. These shifts in production within the eastern counties of England, to the use of light land for the production of both main crop and second early potato production, have important implications for water resource management. These counties are already vulnerable to drought, with the lowest average annual effective and drought effective rainfall levels in the UK and the impact on agriculture is further compounded by favouring light soils which are more prone to drought.

	1990/91	1991/92	1992/93	1993/94	1994/95
DOMESTIC					
Raw loose	2218	2693	2577	2500	2388
Raw prepacked	625	-	-	-	-
Canned / other	15	21	22	24	21
Dehydrated	25	26	37	22	21
Crisped	389	427	506	508	434
Frozen / Chilled	395	463	509	564	457
TOTAL DOM	3667	3630	3650	3618	3321
NON DOM					
Raw	948	850	1082	1534	1252
Canned / dehydrated/ other	300	297	314	263	391
Crisped	207	150	128	177	200
Frozen/ chilled	580	629	818	793	862
TOTAL NON	2035	1926	2341	2767	2706
DOMESTIC					
TOTAL USAGE	5702	5556	5991	6384	6027

Table 5.2: Consumption of potatoes in the UK. (Source: PMB 1996)

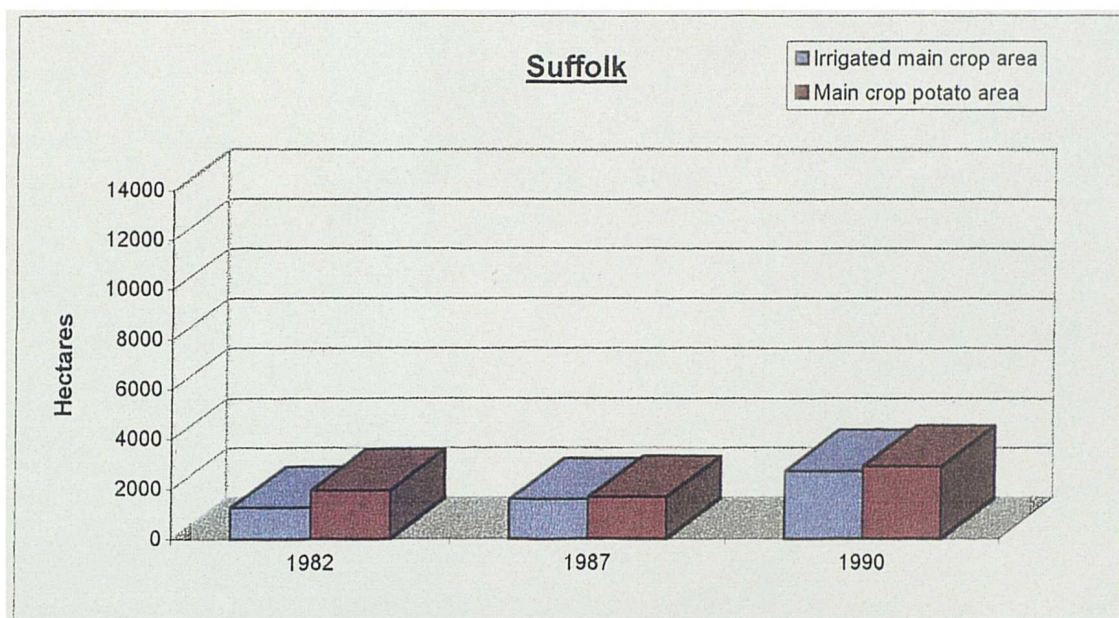
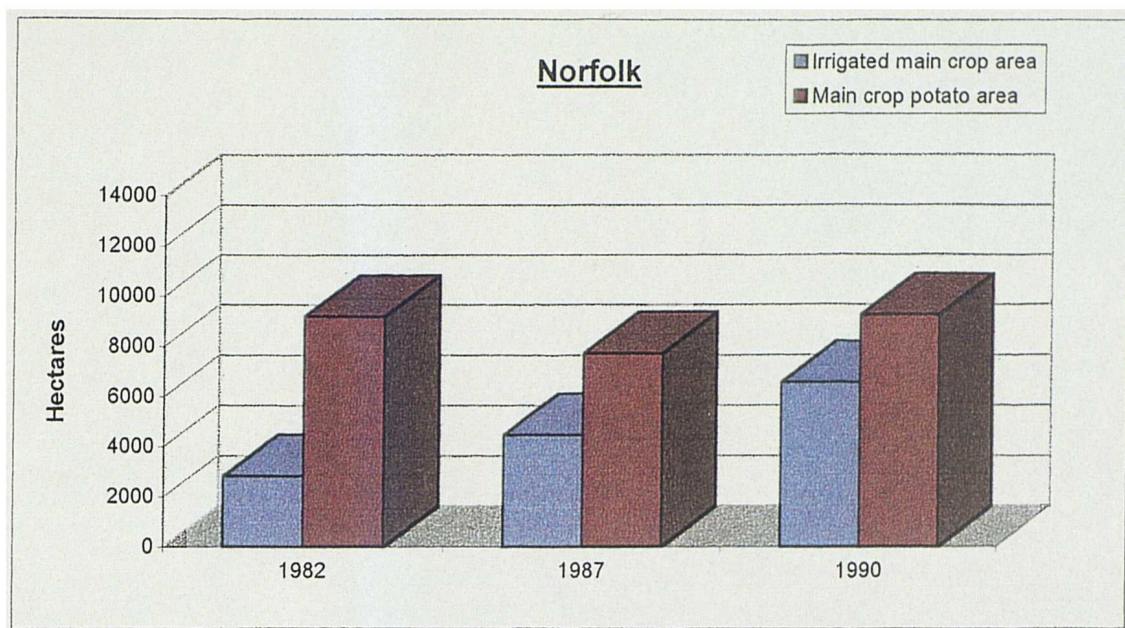
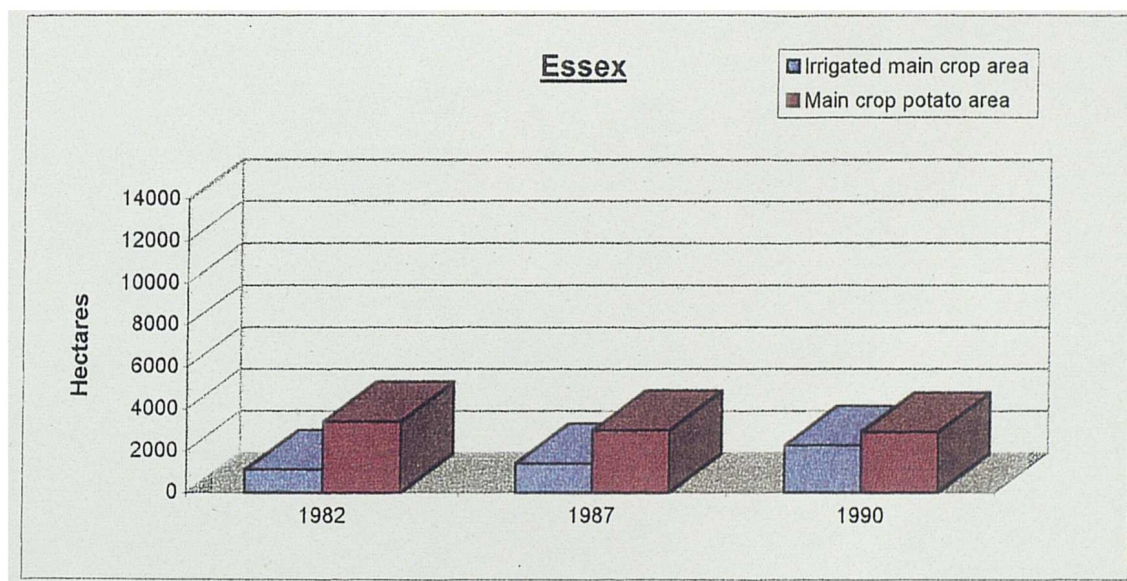
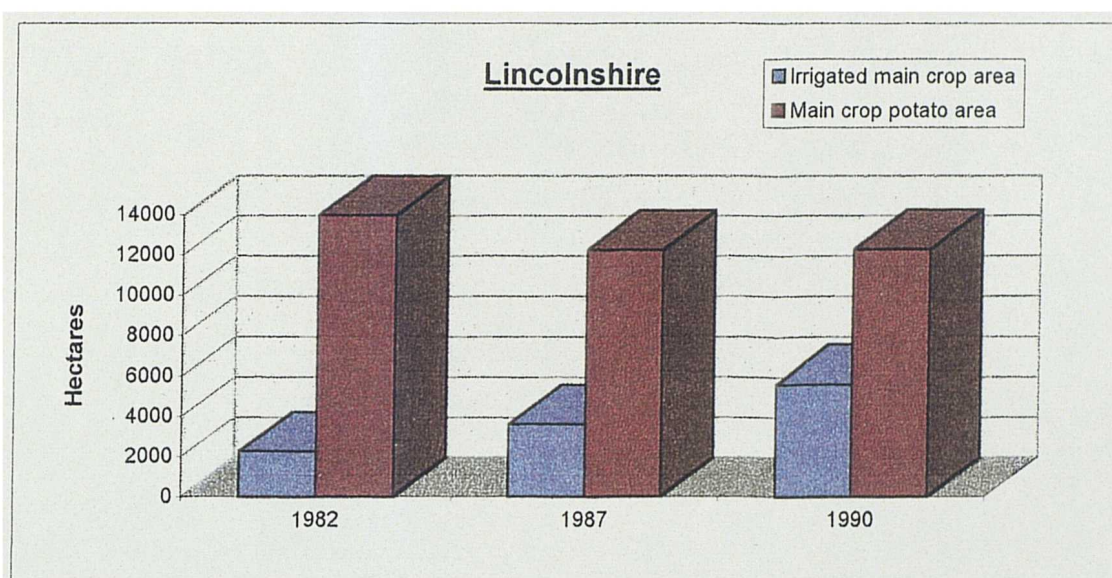
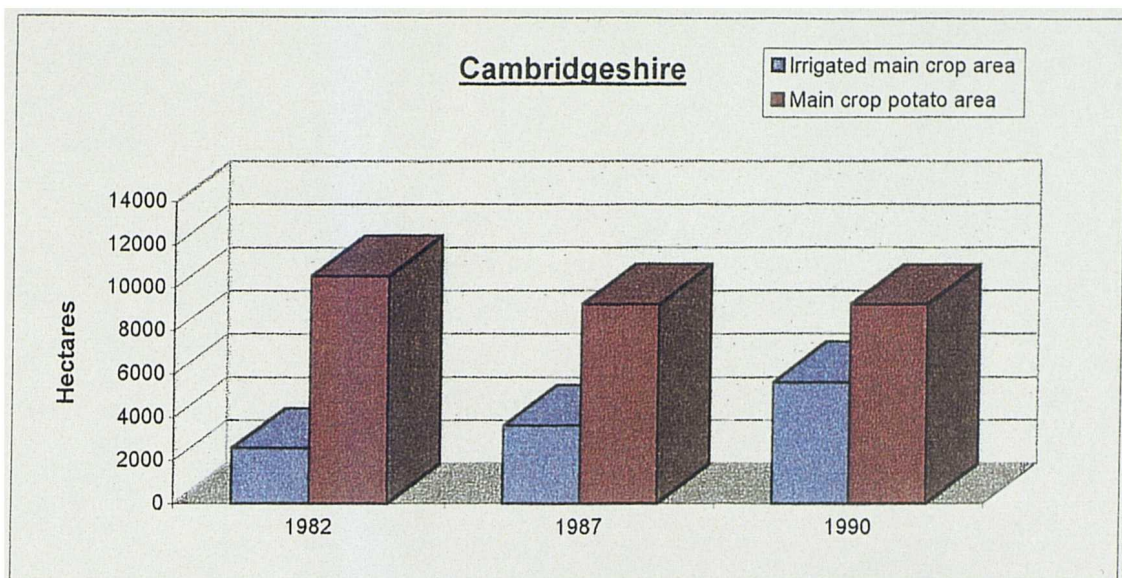


Figure 5.2 : Increase in the proportion of the main crop potato area receiving irrigation.

(Source : Maff 1983, 1988, 1991)



The market for potatoes is divided into the fresh and processed sectors, with a total of 6,027,000 tonnes consumed in the UK in 1994/95 (PMB 1996). There are marked divisions within these sectors, with the fresh market made up of loose, pre-packed and specialist niche potatoes, which are sold through specific outlets namely supermarkets, wholesalers, chip shops and farm shops. The process sector is divided principally into the crisp and frozen chip markets, with the dehydrated and canned markets representing a declining share of total consumption (see table 5.2). The consumption of fresh potatoes has remained relatively stable in both the domestic and catering sectors, with the growth in consumption occurring in processed crisps and chips (see table 5.2). This has translated into a steady increase in the tonnage of raw potatoes procured by the processing companies, which increased in the frozen sector from 668,000 tons in 1990/91 to 954,000 tons in 1994/95 (see table 5.3).

'000 tonnes	1990/91	1991/92	1992/93	1993/94	1994/95
CANNED/ DEHYD/OTHER					
Home grown	152	163	140	149	171
Imported	0	0	0	0	0
CRISPED					
Home grown	595	584	695	693	641
Imported	11	10	2	4	5
FROZEN/ CHILLED					
Home grown	668	742	838	911	954
Imported	38	74	62	53	57
Total UK grown usage	1415	1489	1673	1753	1766
Total processed	1464	1573	1743	1814	1829
Total UK potato production	6555	6267	7802	7065	6445
% processed	21.6%	23.8%	21.4%	24.8%	27.4%

Table 5.3: Estimated tonnage of raw potatoes used in processing in the UK.
(Source: PMB 1996)

National figures on the production of field scale root vegetables, namely carrots and parsnips, are not readily available from reported MAFF statistics. In fact, these crops are subsumed under the heading of outdoor fieldscale vegetables which totalled 127,000 hectares in 1994 (MAFF 1995). The reported value of the carrot crop reached £93 million in 1994, and the higher prices reflected the reduced yields which were a consequence of the cold spring and dry summer (MAFF 1995). Production of these crops are primarily for the fresh market, with the baby carrots and “carrots with tops” evolving as niche products alongside the general loose or pre-pack carrot and parsnip. Carrots are also frozen for the domestic and catering markets, although data on the size of these markets are not readily available.

The general characteristics of the potato processing and marketing companies interviewed in this study are presented in table 5.4. In total 2.3 million tonnes of potatoes are processed or packaged by these ten companies, which represent the market for 45% of total UK farm production in 1994. More significantly perhaps, the five processing companies used a total of 1.3 million tons of raw potato, representing 75% of total consumption in this sector in 1994. The processing companies all operate in the international market and ownership varies from sole family control to public limited company status. Three crisp and one frozen chip processor are subsidiaries of multi-national, agri-food companies with interests across the food production and consumption process ranging from seed and chemical fertiliser inputs, to animal feed stuffs, to snack food production, to food transport distribution companies. These processing companies have developed a combination of direct and indirect linkages across the food chain through ownership or partnership agreements with specialist potato seed producers, membership of international research and development institutes, and their own in-house research programmes. These companies have also developed forward contract production agreements with farmers to ensure production of potatoes.

	Number interviewed	Ownership	Scale	no. sites UK	Customers/ production	total tonnage raw potatoes	Contract agreements	Linkage seed specialists
PROCESSING MARKET Crisp	3	all multi-national	all international	1-3	own brand and supermarket own label	660,000	60-100%	all links
Frozen chip	2	private and multi-national	all international.	1-3	own brand; supermarket own label; fast food brands; catering/hotels	630,000	0-75%	combination
FRESH MARKET Pack house	4	PLC; multi-national	regional - national	1-5	processing crisp; chip; supermarkets; bag trade	620,000	25-50%	all links
Co-op	1	co-op	regional	1	supermarket; bag trade; processors.	400,000	co-op	links
Total	10					2,330,000		

Table 5.4: General characteristics of the potato companies interviewed.

In contrast, in the fresh market the firms primarily operate at the national or regional level, and only one firm is a subsidiary of a multinational company. A total of 1 million tonnes of potatoes are packaged by four of these companies¹, which represented a fifth of the national tonnage in 1994. These companies are also directly involved in potato seed, as producers of seed and through membership of national and international research and development institutes. Direct involvement with farmers, through forward contract production, is confined to specialist niche varieties, but the companies offer a range of specialist production and marketing advice to farmers through the season. The three root vegetable pack-houses are quite distinctive regional companies, whose operations are confined to the Breckland area of Norfolk and the Fenland of Cambridgeshire and Lincolnshire. These companies are family owned and managed and have diversified into specialist pre-packing from their core business of carrot, parsnip, potato and salad crop production. Land ownership ensures these companies retain control of production, with a staff of specialist agronomists and fieldsmen continually monitoring the crops. The companies also lease land with water rights attached on a yearly basis from other farmers in the locality. Details on the actual production system, in terms of the land area and quantities produced, were not forthcoming as the companies claimed this information was confidential. Nevertheless the full extent of this sophisticated system was revealed through the farmer interviews, where a number of farmers leased out their land with water rights (see 6.1.4 for full details).

5.2: The structure of the potato and root vegetable network.

The structural organisation of the potato and root vegetable network provides critical insight into the key mechanisms through which firms directly and indirectly control and manipulate the production and consumption of food. Previous analysis has focused on the interaction between farmers and off-farm firms (Hawkins 1991; Marsden *et al* 1992) but failed to explore the complex inter-relationships within which these firms are themselves embedded. This represents a significant gap,

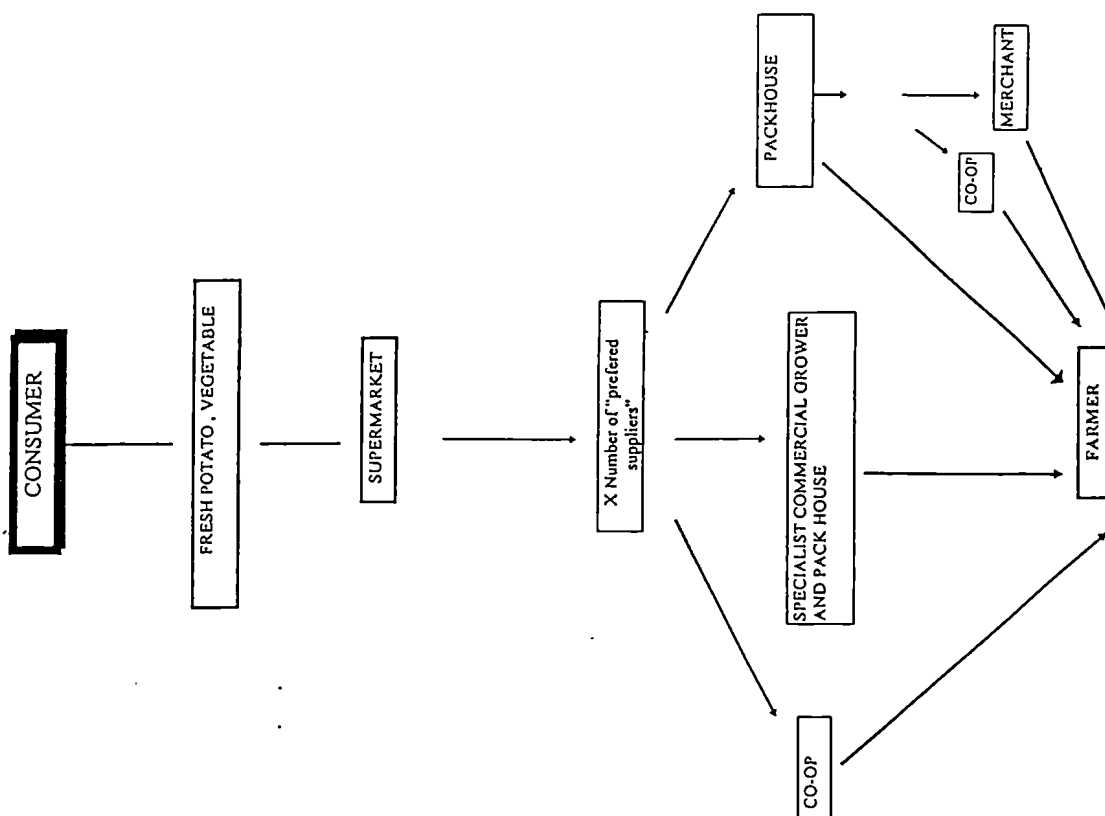
¹ Note, one of the companies refused to reveal figures on the tonnage of potatoes packaged annually.

as interaction with farmers is the end point of a complex and multi-dimensional process of market regulation, as firms within the food network directly and indirectly shape and manipulate each other's behaviour. The form and function of these inter-linkages and the relations of power and dependence which underpin them, are central to understanding the way firms shape and influence on-farm production decision making.

Economic theory has traditionally concentrated on two forms of inter-firm linkage, namely vertical integration and independent transactions in the market place. Vertical integration is assumed to reduce uncertainty over the supply and price of raw material inputs (Crew 1975) through the linear consolidation of the entire production process under the control of a single firm. This has been viewed by traditionalist and Marxist geographers as an unproblematic process, driven by economies of scale and the reduction of transaction costs or the inevitable consequence of the centralising tendencies of capitalist accumulation (see Holmes 1986 for a full review of this literature). Neo-classical economic analysis, in contrast, assumes all firms engage in cost rational decision making in which all firms are independent and equal. Nevertheless, between these two extremes there are a number of alternatives which suggest vertical integration within firms or commodity sectors is not inevitable and that subordinate firms may occupy important structural positions (Fitzsimmons 1986; Holmes 1986; Ekinsmyth *et al* 1995).

This is clearly the case in the UK food sector, where vertical integration between supermarkets, food processors, food manufacturers, pack-houses and farmers has failed to occur (Marsden and Wrigley 1994). In fact the relationships which connect the producers and consumers of food cannot be characterised as simple, nor linear type system in which market exchange occurs between equals. In reality, farmers, as the producers of food, have been reduced to little more than the suppliers of raw material inputs, which are progressively transformed and re-valued by successive manufacturers, packagers and retailers before finally arriving on the supermarket shelf (Munton

PART A.



PART B.

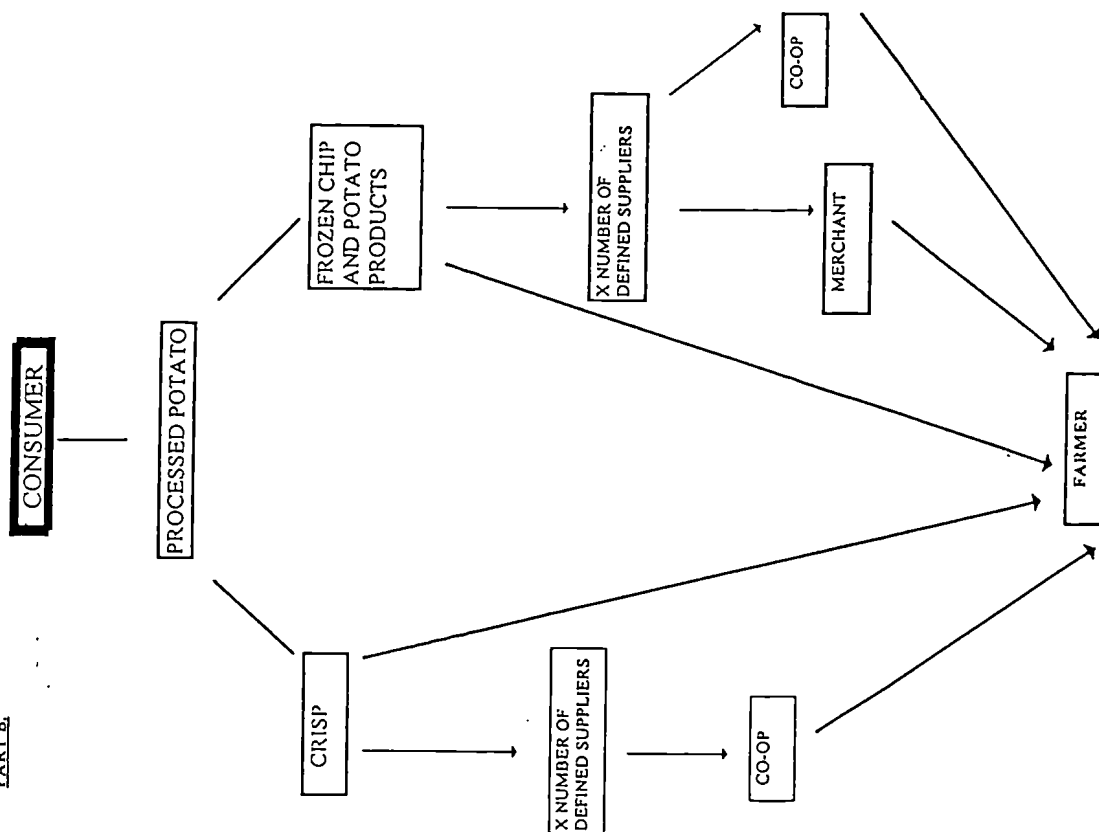


Figure 5.3: The network of inter-firm linkages in the fresh and processing potato networks.

1992; Marsden and Arce 1995). These relationships are complex and multiple, as firms are tied together through a network of inter-linkages which are maintained and reinforced by flows of capital and information to control and regulate the production and consumption of food. The relations of power and dependence which underpin this network are critically important, enabling detailed exploration of the ways in which the supermarkets and processors exploit their position to manipulate the decision making of subordinate firms and, by implication, farmers. This is evident in the potato and root vegetable sectors, where the analysis identifies a complex network of inter-firm linkages which control and regulate the operations of the surveyed firms (see figure 5.3). The analysis distinguishes between the fresh and processed potato networks, where there are marked differences in the form and function of the inter-firm linkages.

5.2.1: The fresh potato network.

The fresh potato network identified in figure 5.3 Part A concentrates on the web of linkages, through which supermarkets control and regulate the production and consumption of fresh potatoes. This represents the quality end of the market, which sells niche salad, pre-pack, baking and loose potatoes, as opposed to the wholesale and chip shop trade which concentrates on bulk supply. The organisation of potato procurement in both the supermarkets interviewed is based around a team of produce buyers and potato technologists. The responsibilities of these personnel are divided along technical lines, with the buyers primarily responsible for ensuring a constant supply of potatoes to the stores on a weekly basis. They are also responsible for spotting and developing new market opportunities, which in the potato sector relate to new niche varieties. In contrast, the potato technologists are responsible for ensuring the quality of the potatoes and compliance with health and safety legislation.

The supermarkets have no direct contact with the actual growers, working instead through a pool of between 8-10 specified potato suppliers, or “preferred suppliers”. This procurement strategy represents a significant shift in emphasis away from the wholesale spot market and the use of merchants and evolved in the early 1990s in response to the introduction of British Standard BS5750. The changes to these inter-firm relationships reflect, in part, the unintended consequences and side effects which result from this new State regulation. A central element of this standard is the traceability of produce, which ensures a potato can be traced, for example, from the seed to the supermarket shelf, ensuring full knowledge of all chemical applications used on the seed, in the field and in storage. Merchants operating on the spot market are unable to guarantee the provenance of produce, and thus the supermarkets are themselves legally liable if any produce on their shelves actually break the standards. In consequence, working through a pool of suppliers the supermarkets are able to ensure all produce meets the legal requirements by stipulating each supplier signs a declaration on product quality assurance. This is drawn up by the supermarkets and incorporates the key elements set out in BS5750, ensuring legal responsibility for traceability is shifted from the supermarket to the supplier. The supermarkets, through the potato technologists, police this system and ensure compliance through audits and unannounced spot checks at each supplier.

The potato technologists are also responsible for the development of the produce quality criteria, which are specifically designed for each segment of the potato market. In conjunction with the team of buyers, the potato technologists draw up a list of between 8-10 preferred potato varieties, which the stores will stock over the year. Quality specifications are drawn up specifically for each variety, and the information is then relayed to the pool of suppliers. Although the supermarkets set out strict conditions of supply encompassing the quality specifications and standards on health and safety, there are no written contracts with the supplier specifying the actual price, delivery date or quantity to be supplied through the year. This ensures the supermarkets retain a flexible approach and are able to take advantage of quality or price variations in the wider market.

The pool of supermarket suppliers includes two distinct types of commercial operation, namely farmer co-ops and commercial pack-houses who supply a range of differential quality potatoes, not only to supermarkets but also to wholesalers, pre-packers, chip shops and processors. The form and function of the inter-relationship with farmers is markedly different in each of the groups.

The co-ops have a committed number of farmers who grow a set area of potatoes which are overseen by co-op agronomists and fieldsmen. Although there are no direct contracts between the co-op and farmer, setting a price for the supply of supermarket standard potatoes, the co-ops do guarantee a market outlet for the crop whatever its quality. The co-op agronomists critically influence and shape the potato marketing strategy of the farmer by providing information and advice on the suitability of particular varieties to their land and water resources. Individual meetings are held with farmers in the autumn to discuss the harvested crop and to plan the following year's production. The agronomist advises on the market sector which the farmer is best suited to, on the basis of past performance, land and soil type, availability of irrigation water, storage facilities, harvesting equipment and the cash flow requirements of the farmer. On the basis of this information the agronomist will suggest the most suitable market sector, and in consequence the potato variety. All subsequent advice relates to the growth characteristics of the variety, with the agronomist providing pre-season information on the seed spacing rates, fertiliser, pesticide and herbicide application, when to trigger the first irrigation application, when to spray off the crop² and when to harvest. Through the season, fieldsmen visit once every seven to ten days to monitor the crop and provide advice on specific problems. This close contact enables the fieldsmen to ensure farmers record all information relating to fertiliser, pesticide and herbicide applications, thereby complying with BS5750.

² This management procedure is a vital pre-harvest operation, which kills off leaf and stem growth on the potato plant and succeeds in speeding up the tuber skin setting process, avoids the onset and spread of disease and controls the size of the potato tubers.

The co-op has developed close contacts with farmers playing a key role shaping and manipulating on-farm production decision making to ensure produce conforms to the supermarket quality and health and safety standards. This is in the interests of the supermarket which benefits not only from the local knowledge and contacts of the co-op staff, but also, the close contact between co-op staff and farmers means that the co-op effectively polices production to ensure compliance with the quality and safety standards set by the supermarket. Thereby the supermarket avoids incurring any of the financial costs of regulating production.

In contrast, the second group of suppliers, namely the potato pack-house companies, maintain minimal direct contact with farmers, using a pool of other companies, predominantly farmer co-ops but also merchants to supply potatoes. The companies are active in the national potato market and supply specialist niche salad, pre-pack and baking potatoes to their supermarket customers. These companies operate two distinctive potato procurement strategies, with all salad niche varieties grown on forward contracts with farmers. The procurement of standard pre-pack and baking potatoes adopts a markedly different approach with no direct involvement with farmers, working instead through a pool of defined suppliers who have sole responsibility for ensuring the procurement of these potatoes. The suppliers sign a declaration, issued by the pack-house, which incorporates the key elements of BS5750 and relays the quality specifications set by the supermarket. However, there are no contracts of supply between the pack-house and supplier, who relies on weekly negotiations on price, quantity and delivery dates.

The form and function of the inter-firm linkages in the fresh potato network are clearly defined and manipulated by the supermarkets, who have used their position of dominance within the food sector to control at arms length the production and consumption of potatoes. The supermarkets have established and maintained an effective network of control by procuring potatoes through a pool of defined suppliers. This strategy enables them to control and regulate the flow of information and

capital to other parts of the network, without incurring any of the financial and legal costs or risks associated with close liaison with farmers, and is typified in the supermarket response to the implementation of BS5750. When the standard was first introduced, the supermarkets were open to legal prosecution, as their procurement operation failed to comply with the new standard and they were unable to trace the produce on their shelves through all stages of the production process. Restructuring their procurement strategy enabled the supermarkets to shift the risk of legal prosecution, by ensuring responsibility for the traceability of produce rested firmly with their suppliers. Consequently, it is the responsibility of the pool of preferred suppliers to ensure all potatoes sold to the supermarkets are traceable, with access to all records on the crop history relating to the use of all chemical inputs used on the seed, in the field and in storage. The introduction of the new BS5750 has had a number of unintended consequences and side effects which were not foreseen when first introduced by Government and reinforce the position of the supermarkets as the new regulators of the food system, as they effectively take on responsibility for policing the implementation of BS5750 through audits and unannounced spot checks.

The role of the suppliers within this network is critical, as they are the central point, or channel of negotiation and representation between supermarkets and farmers. These firms are used as “social carriers” (Marsden and Arce 1995) by the supermarkets, who take advantage of their close contact with farmers at the local level to relay and enforce the supermarket quality specifications. The position of these subordinate firms is critical, enabling the supermarkets to control production at a distance, without incurring any of the legal or financial risks and uncertainties associated with vertical integration.

5.2.2: The potato processing network.

The potato processing network has undergone major restructuring over the last 5 years, with a movement away from the use of potato merchants to greater direct contact with farmers. Figure 5.3 Part B underlines the close linkage between processors and farmers, with forward contracting the key mechanism of ensuring supply. Change has been most dramatic among the crisp processors, who had previously procured up to 50% of their potato raw material demand through merchants. This figure has dropped significantly, with 70-80% of potatoes now supplied through forward contracts with farmers. The supply shortfall is made up through the purchase of excess tonnage produced by contract farmers, and in periods of extreme shortage, through merchants.

The switch in procurement strategy reflects the increasing competition between processing firms, which are attempting to increase market share in a highly competitive international market. As part of this strategy, the firms are now developing potato varieties which are specifically tied to their end potato products, as well as strict quality criteria which are also related to these varieties. Confidentiality is the key to ensuring competitors do not gain access to this critical inside information, and the merchants are unable, given the nature of their operation, to guarantee this. By cutting out these intermediaries and dealing directly with farmers, the processors are better able to retain confidentiality while at the same time strictly monitoring and enforcing quality at the farm level.

The procurement of potatoes is organised by a team of buyers and agronomists, with responsibilities divided along purely technical lines. The buyers are primarily responsible for negotiations with farmers over the contract, while the agronomists co-ordinate advice to farmers, develop the quality standards, organise the seed sourcing operation and the research and development programme. All the company agronomists provide detailed information to the farmer

on the particular growing characteristics of the potato variety, but only one company supplements this information with actual farm visits through the season to regulate and monitor production.

The nature of the inter-firm linkages in the frozen chip network does not reflect the same level of organisational uniformity, with the firms adopting markedly different approaches to the procurement of potatoes. This does not reflect differences in market position, as both companies produce leading own brand products, as well as producing, on contract, own label products for fast food, catering companies and supermarkets. Nevertheless, there are marked differences in the total quantity of potatoes procured, with the larger user developing a procurement strategy in line with the approach adopted by the crisp companies. Thus, a declining proportion of potatoes are procured through merchants and there is greater reliance on forward contracts with farmers.

In contrast, the other company has no involvement with farmers, procuring all potatoes through a pool of defined suppliers, including co-ops and merchants, spread across the UK. This procurement strategy developed in response to the restructuring of the company, which forced the closure of the agronomy department and consequent job losses. Hence constraints of capital and labour prevent closer involvement with the farm sector. Consequently, although the company uses a list of preferred potato varieties this is not strictly adhered to and the firm uses whatever varieties, of whatever quality are available on the market at the time, to ensure a continuous supply through the factory. The nature of the inter-relationship with the pool of suppliers is not therefore overly restrictive, as the company does not attempt to reduce supply uncertainty through strict specifications on variety or quality. This company however is the exception, as all the other processors interviewed have attempted to reduce uncertainty over the supply of potato raw materials through forward contract production.

5.2.3 The root vegetable network.

The form and function of the inter-firm relationships in the root vegetable network are distinctly different to the relationships noted in the fresh and processing potato networks. Although the supermarkets, once again, devolve procurement of carrots and parsnips to a pool of preferred suppliers, the pack-houses have a markedly different relationship with farmers. In fact, the three pack-houses interviewed in this network, directly control production through the vertical integration of the entire production process under their sole control. Thus, as the owners of land they are able to directly regulate and control production to ensure produce conforms to the supermarket quality specifications. These companies operate highly sophisticated, capital intensive systems of production with specialist planting and harvesting machinery, agronomists and fieldsmen monitoring the crops in the field and staff employed in the harvesting and packaging of the crops in individual pack-houses. The expansion of production by these companies is dependent on the acquisition of more land with water rights attached. Consequently, these companies also rent land with water rights attached from other farmers on a one year seasonal contract or a lease back, swap arrangement. This complicated system enables the pack-house firm to grow a set area of carrots or parsnips on other farmers' land; these farmers then grow sugar beet or wheat as a break crop on the pack-house's own land. No money changes hands, and each partner in the arrangement is wholly responsible for all production decision making on their crop.

This system is supplemented by formal lease arrangements, and within the Breckland area the companies compete among themselves in order to rent light sand land with water rights attached. Land without water rights is not considered, as the risks of producing the crop without irrigation are too high. In consequence, the pack-houses reserve a set quantity of water from the farmers' total licensed quantity at the beginning of the season. The farmers are typically paid £150-200 per acre for the land and £25-40 per acre inch for the actual water. Labour and pumping costs are included at the end of the season, depending on actual usage. Although the farmers have no involvement in

decision making in relation to the crop, they do set up and manage the irrigation system often using their own irrigators, and trigger an irrigation application on the direction of the agronomist or fieldsman.

The historical development of these firms provides critical insight into the key processes influencing the development of their root vegetable procurement strategy, as they all started off as farmers, producing carrots and parsnips for sale on the spot market. The financial risks of production, reflected in the extreme fluctuations in produce prices as well as the differential between farm gate and supermarket prices, forced these firms to diversify into pack-house operations in order to reduce the risks and uncertainties of marketing the crops. By adding value through packaging the crop, the firms were able to reduce the financial risks of price fluctuations and deal directly with the supermarket customers, thus reasserting control over the off-farm exchange process.

The organisational structure of the fresh and processing potato and root vegetable networks underline the complex nature of the inter-firm relationships which underpin the food network. The analysis demonstrates how the supermarkets and processors have successfully avoided vertical integration, while at the same time refuting the contention of neo-classical economic analysis that firms engage in cost rational decision making in which all firms are equal and independent. In fact the analysis reveals the unequal balance of power within the food network, as the supermarkets and processors are able to dictate the terms of trade to subordinate firms and farmers who occupy an important structural position within the network. In fact both the supermarkets and processors reformed their produce procurement strategies in the late 1980s and early 1990s in response to new Government legislation and the quest to maintain and increase market share. In consequence, the form and function of their inter-relationship changed, with the supermarkets reallocating specific duties and responsibilities to subordinate firms, while the processors withdrew from their

involvement with “middle men” and refocussed their procurement strategy solely on farmers. This resulted in the supermarkets and processors concentrating their procurement strategy on specific supply firms, and farmers insuring they inter-locked more precisely with their centrally controlled, logistically efficient operations. The supermarkets and processors effectively control their respective networks, which enables them to avoid all the financial risks and uncertainties associated with vertical integration, while at the same time benefiting from all the associated benefits, namely a reliable, consistent supply of produce which conforms to Health and Safety legislation, quality and price specifications. This asymmetrical bargaining power enables the supermarkets and processors to manipulate and regulate the operations of subordinate firms and farms, successfully reallocating the risks and uncertainties associated with production for others to bear.

5.3: Networks of quality: implications for the use and management of irrigation water.

The supermarkets and food processors have successfully exploited their position of economic power within the food network, to manipulate and control production without incurring any of the financial risks of vertical integration. One of the key mechanisms, through which they exert control over the production process and extract value, is the definition of precise produce quality criteria. These criteria attempt to ensure the uniformity of produce in terms of colour, shape, size, appearance and taste and require the direct manipulation and control of on-farm production decision making. In both the fresh and processed potato networks, there are competing definitions of quality, with different emphases given to different factors depending on the end use of the potato. Despite this variability, the quality criteria have critically important implications for on-farm management, particularly irrigation use, as it is one of the only management tools which can control two of the most important quality dimensions, namely potato size and skin finish.

In the fresh potato network the supermarkets are the driving force behind the continual refinement of quality standards, as they attempt to increase the value added to the final product and create new

markets. This is reflected most clearly in the actual marketing of potatoes in store, with the movement, over the last 5 years, away from the sale of loose potatoes with no identification of variety or cooking purpose, to an increasingly nichified or segmented approach. Thus, potatoes are now clearly marketed either by purpose, for example, chipping potatoes, baking potatoes or salad potatoes; or by variety for example Maris Piper, King Edward, Cara or Charlotte varieties. These potatoes are rarely sold in loose form and the standard practice across the supermarkets is the packaging of pre-washed potatoes in packs, punnets or pre-weighted bags. As a consequence of this marketing strategy the appearance, and most importantly the skin finish of the potato, has become increasingly critical to their saleability.

Each supermarket develops a list of preferred potato varieties, which succeeds in restricting choice to 8-10 pre-selected varieties, chosen on the basis of past sales performance and market research. The supermarkets undertake customer testing of the potatoes primarily among their own staff, but also occasionally extended to the general public. Blind tests score the different potato varieties against four key criteria namely taste, cookability, appearance and texture. This information then feeds in to the choice of potato variety, and the design of the quality criteria (see table 5.5). The choice of potato variety critically shapes and influences the quality specification and by extension critically determines the use and management of irrigation water at the farm level.

FRESH POTATO MARKET		PROCESSING POTATO MARKET	
Supermarket (A)	Fish and Chip trade(B)	Crisps (C)	Chip and potato products (D)
niche salad crop i. variety specific ii. skin finish iii. size and shape iv. damage, internal bruising v. disease vi. cookability Baking potato i. variety specific ii. skin finish iii. size iv. damage and internal bruising v. disease vi. cookability Pre-pack potato i. variety/ purpose specific ii. skin finish iii. damage and bruising iv. fry colour v. dry matter vi. size and shape vii. cookability Favoured varieties Cara; King Edward; Maris Piper; Maris Peer; Desiree; Marfona; Jersey; Pink Fir Apple; Belle de Fontenay; Asparge; Esteema	i. variety specific ii. fry colour iii. dry matter iv. size v. damage vi. disease vii skin finish Favoured varieties Maris piper	i. variety specific ii. size and shape iii. dry matter iv. sugar levels/ fry colour v. damage vi. disease vii. skin finish Favoured varieties Lady Rosetta; Record; Saturna	i. variety specific ii. fry colour iii. sugar levels iv. size v. dry matter vi. damage vii. skin finish Favoured varieties Russet Birbank; Shepody; Yukon Gold; Maris Piper; Pentland Dell.

Table 5.5: Central dimensions of potato quality.

All potato varieties have variable tolerance to drought, which reflects their capacity to yield tubers under conditions of water stress. The potato varieties favoured by the supermarkets (see table 5.5 column A) include three varieties King Edward, Maris Piper and Maris Peer which have very low levels of drought tolerance (NIAB 1995), and therefore require irrigation even under normal weather conditions. Of critical importance for on-farm water use, potato varieties also offer variable resistance to common scab, which is one of the most widespread diseases affecting potatoes, leading to significant loss of skin quality (Bailey 1990). Irrigation application is the only management tool which actually controls this disease, and water must be applied to ensure the soil moisture deficit level (SMD) does not fall below 15mm for a critical 4-6 week period following tuber initiation (see Bailey 1990 for full details). In fact, six potato varieties included on the supermarket lists show low to moderate resistance to common scab (NIAB 1995), and irrigation is therefore a vital element of production.

These problems are further compounded by the quality specifications which are drawn up for each variety. The appearance of the potato is vital for all varieties whatever their end use, particularly as supermarkets now sell pre-washed and packaged potatoes which clearly expose any minor imperfections. Skin finish is obviously the most important element of potato appearance, and the level of common scab is vital. The supermarkets will not tolerate any scab on salad or baking potato varieties, and will only accept scab on chipping or general purpose varieties, if the scab covers less than 5% of the potato, is confined to the skin's surface and can be removed in one peeling. These exacting specifications place severe pressures on farmers to produce scab free potatoes, and encourage them to adopt an intensive irrigation regime. In fact, if farmers maintain the soil moisture deficit levels at 15mm for the requisite 4-6 week period, calculations suggest that up to 50% of the total water applied to the crop is used to control common scab. Irrigation in this phase of growth does not produce any other benefits in terms of the size of the tubers or yield, which are both improved through irrigation in the later stages of growth. Another vital element of potato

appearance is the presence of cracks which develop as a consequence of water stress and a stop-go growth pattern (Bailey 1990). Hair line cracks are only tolerated if they can easily be removed by peeling.

The second critically important dimension of quality is the size and shape of the potato, particularly in salad and baking varieties. Baking potatoes are defined within a 60-80mm size grade, with an oval shaped tuber. To some degree farmers are able to control these variables by varying the seed spacing rate. Nevertheless, the most important management tool influencing the size of the tubers is the application of irrigation water in the later stages of the growth cycle to aid the “bulking up³” process. Thus, in combination with the clean skin finish, farmers are expected to instigate an intensive irrigation regime which controls the incidence of common scab in the period immediately following tuber initiation; ensure that the plant does not suffer any water stress leading to growth cracks in the middle phase of growth, and then apply water in the later stages to ensure the tubers meet the correct size specifications. Consequently, irrigation is vital to the production of the “perfect” baking potato.

The size and shape of the salad varieties are also carefully defined with the Charlotte variety expected to conform to a long, oval shape, with the tuber diameter ranging from a minimum of 20mm to a maximum of 45mm, and the length ranging from 25-100mm. To ensure the tubers conform to this long, oval shape, production is confined to the light sand lands. In consequence, irrigation is vital to ensure against the problems of scab, which is particularly prevalent on sand land, and ensure water stress does not create problems of growth cracks or misshapen tubers. The growing season for these varieties is relatively short and in theory the demand for water should be less. However, these varieties are often produced under double cropping systems, whereby one crop

³ Bulking up relates to the increase in size and weight of the tubers.

is harvested and then another immediately planted, thus placing greater stress on water resources, as the second crop is more susceptible to drought as the soil moisture levels are often depleted.

The third critically important dimension of quality is the level of tuber damage and bruising, which is primarily controlled through the harvesting and storage procedures on the farm and in the pack-house. Damage to the actual tubers such as scarring or removal of chunks of flesh, develop as a consequence of mishandling when lifting the potatoes in the field, and poor machinery and labour practices are often blamed. This is a critically important dimension of potato quality, which the supermarkets are unwilling to relax, even in periods of shortage. The fourth dimension of quality relates to the storage “potential” of the crop and the presence of any blemishes or diseases which may subsequently develop into serious problems such as silver scurf, black scurf and skin spots on tubers. Hence, the potato entering storage must be unblemished, and irrigation is therefore essential to ensure an even pattern of growth without water stress. The final dimension of quality focuses on the cookability of the potato, and is particularly important for chipping and general purpose varieties. In fact the dry matter levels are critically important and are defined in a range of 19-23% dry matter to ensure the crispness of the final product.

The specification of strict variety and quality criteria serves to reduce uncertainty over the supply of potatoes, as supermarkets attempt to ensure a consistent supply of uniform potatoes which conform to their definition of the “perfect” potato. Significantly, this process also enables the supermarkets to differentiate between different potato “qualities” in terms of the variety, use or appearance, to create new markets which re-constitute or add value to a staple product of the UK diet. The development of baby salad potatoes perhaps best exemplifies this process as the supermarkets have re-valued and re-labelled small potatoes into a new niche or exotic potato product. The quality criteria are central to the creation of these new potato markets, and a vehicle for the transfer of surplus value from the farmer to the supermarket.

In the processing potato network the quality specifications, although different, are no less exacting with marked distinctions between the criteria for chip and crisp potatoes. All the crisp and one of the chip processors interviewed work with a list of preferred potato varieties which are closely matched to specific end products. The choice of these varieties is closely assessed against four key criteria, namely consumer acceptability, process efficiency, on-farm production complexity and environmental friendliness which is only slowly being incorporated into the assessment. Consumer acceptability is acknowledged as the most important criterion, and the final products are tested in market research where the taste, appearance, crunchiness and colour of the different products are assessed by consumers. Different varieties are used in the final product to evaluate their acceptability. The second key criterion examines the process efficiency of the different varieties within the factory. Variations in terms of the dry matter levels or reducing sugar levels critically influence the processing of the raw material inputs. For example, potatoes with low dry matter levels will absorb more oil when cooked, thereby increasing costs and leading to a less crisp or crunchy end product. In addition, low reducing sugar levels are critical to ensuring production of the pale coloured crisp, favoured in the consumer tests and additional processing such as bleaching the raw potato may be necessary to remove the excess sugar. These considerations are critically important, as the companies attempt to reduce uncertainty, costs and variability within the production process. The consistent supply of raw material inputs which conform to the same standards thereby ensures the production of a uniform end product.

The third criterion, on-farm production complexity, relates to the viability of producing the variety in UK agricultural conditions given the constraints of climate and land resources. Obviously, the vulnerability of the variety to drought and water stress is a factor which should be evaluated at this stage. However, it is not incorporated into the current assessment criteria. The final criterion, environmental friendliness, has only been introduced in the last 2-3 years and has been

incorporated by one company into their research and development programme, reflecting their response to new environmental policies emanating from Government and the EU. To date they have only focused on the use of chemical inputs namely fertilisers, pesticides and herbicides and are examining the use of alternative varieties which demand less nitrogen and are susceptible to fewer diseases requiring herbicide or pesticide applications. This approach has evolved in response to the NSA and NVZ schemes and the potential extension of even tighter controls in order to prevent groundwater pollution and protect drinking water quality.

These criteria, in combination, determine the choice of potato variety, with the crisp processors today favouring Saturna, Record and Lady Rosetta while the chip processors prefer Russet Birbank, Shepody, Maris Piper, Pentland Dell and Yukon Gold (see table 5.5 column C and D).

Nevertheless, the choice of varieties is not solely the responsibility of the processors as some of their own customers, primarily for chip potatoes, favour the use of certain varieties which conform to their own corporate definition of the perfect chip. A good example is McCain Chips, which is the main UK producer of chips for the MacDonalds chain of fast food outlets. MacDonalds specify in their contract with McCains the use of the Russet Birbank, Yukon Gold and Pentland Del varieties which ensure the processing of chips which conform to the ideal end product, namely a long, thin pale coloured chip.

The resistance of these varieties to drought is variable with Russet Birbank, Saturna and Record in particular showing very low resistance, while Yukon Gold and Pentland Dell only show moderate resistance levels (NIAB 1995). This in-built susceptibility to drought is further compounded by the crisp processors insisting that all their varieties are grown on light sand or sandy loam soils, which have a low soil moisture retentive capacity and are prone to drought. In consequence, these varieties are prone to even minor fluctuation in rainfall or short dry spells and irrigation is, therefore, vital to ensure the growth of the crop through the season.

The quality criteria which the processors have developed are specifically related to the variety and end use of the product and comprise three critically important dimensions. Firstly, the dry matter levels, which reflect the proportion of the tuber which is not water, must range between 20-23% dry matter in both crisping and chipping potatoes to ensure the correct level of crunchiness or crispness of the end product. Secondly, the reducing sugar content of the tubers should range between 0.10-0.20% to ensure the correct colour of the final product. These quality dimensions are only indirectly influenced by irrigation application, as problems only occur if a stop-go growth pattern is established. The application of water through the season ensures an 'even' pattern of growth and prevents problems of sugar spotting or uneven fry colours. The third critical dimension of quality relates to the size and shape of the tubers. The tubers must be an even shape and size, which range between 45-65mm. Irrigation through the season prevents the onset of misshapen tubers and aids the bulking up process, thereby ensuring the tubers conform to the size specification. These are the three most important dimensions of quality, which the processors rarely relax. Nevertheless, there are two further factors which also play a role, and failure to comply to these specifications can lead to the rejection of the crop. Skin finish, although not as vital as in the fresh potato network, is only tolerated within certain limits; thus if the scab is very deep and cannot be removed in one peeling, the sample is rejected. Tolerance to tuber damage and bruising is also limited and once the levels fall below a defined level the crop is rejected.

The specification of strict variety and quality criteria in the processing potato network succeeds in reducing uncertainty over the supply of raw material inputs, as the processors guarantee a constant supply of potatoes for the factory. In addition, the processors also reduce a significant source of variability and uncertainty within the factory production process itself. A consistent supply of uniform potatoes ensures a standardised production process, thereby increasing efficiency and reducing the costs associated with production within the factory.

The market for carrots and parsnips is relatively undifferentiated, with limited scope for adding value to the end product and developing new niche products. To date this process has largely concentrated on the development of early carrots, parsnips, carrots with tops, and baby carrot products. In consequence, the quality criteria are not designed to suit specific varieties or end purposes and are therefore broadly similar, relating to the length, width, shape and skin finish of the carrot or parsnip. To ensure production conforms to these criteria, all carrots and parsnips are grown on light, sand land which is the optimal growing medium and prevents shape distortion. Irrigation water is vital to ensure the growth of the crop, as light land is susceptible to drought and under these conditions the crop withers and dies. Thus irrigation is vital to guarantee the growth and yield of the crop and only marginally improves quality.

Risk and uncertainty play a central role shaping the form and function of interaction between firms and between firms and farmers in the fresh and processing networks, and this is reflected in the specification of strict variety and quality criteria. Ekinsmyth *et al* (1995) argue that the overriding issue for firms is the reduction of risk and uncertainty within both their production and marketing operations, and the behaviour of the supermarkets and processors conforms to this. The analysis demonstrates how supermarkets and processors attempt to reduce the risks and uncertainties associated with the procurement of potatoes to fulfil demand within the factory and from the final consumer. The firms are responding to different types of risk in different ways and reflect the multi-dimensional nature of the concept (Royal Society 1992). Firstly, the specification of strict produce variety and quality criteria enables the supermarkets and processors to exert greater control over the flow of produce through their factories onto their supermarket shelves. Reducing uncertainty over the supply of produce is critical, to reduce the variability associated with the quality of potatoes and ensure they all conform to the same “homogeneous” standards. This strategy enables the processors, in particular, to reduce the financial costs associated with producing the end product. A

water at the farm level. Farmers become wholly reliant on access to, and use of, reliable supplies of irrigation water to ensure production of the 'perfect' potato and the consequent price premiums. Nevertheless, by adopting this management route they also become more vulnerable to the hazards of low rainfall, drought and associated abstraction restrictions. Farmers' ability to resist these processes of change are limited, as both the supermarkets and processors use their positions of market domination to control and manipulate production decision making through direct and indirect linkages with farmers and input suppliers.

5.3.1 Regulating quality at the farm level: direct and indirect mechanisms of control.

The form and function of the inter-firm linkages in the fresh and processing potato networks were explored in section 5.2, and it is postulated that these processes of market regulation have critical implications for the inter-relationship between firms and farmers. Two key mechanisms of direct and indirect regulation are identified: namely forward contract production and manipulation of the flow of information and inputs to the farm. The analysis of these issues will draw on the postulates set out in the literature on risk and uncertainty, exploring the contention that forward contracting enables firms to externalise the risk and uncertainties associated with production for other sub-contracting firms to bear (Balch and Wu 1974; Ekinsmyth *et al* 1995). In the potato networks, forward contracting features predominantly in the processing network, although contracts are also used to ensure the production of niche varieties in the fresh potato network.

Forward contract production in the processing potato network is used predominantly by the crisp companies with only one chip processor actually using contracts to ensure supply. The proportion of potatoes actually procured through contracts has increased significantly (see section 5.2.2 for full discussion of reasons) and now represents between 70-100% of their raw material supply. The relationship between the processor and farmer is unequal, and is entrenched in the forward contract agreement. The interests of the processors predominate in negotiations, as they attempt to secure

production of a target tonnage of preferred potato varieties. Discussions commence prior to the start of the growing season, when the processor contacts growers who have successfully produced quality potatoes in previous years. Other farmers, who contact the company showing interest in contract production, are assessed to gauge their suitability. Four key factors form the basis of the assessment exercise which are conducted by company staff through farm visits. Firstly, the farmers' past performance, in terms of potato yield and quality are examined, paying particular attention to the consistency of yield results and uniformity of quality. The second factor, which is critically important, concerns the land and soil type. Crisp companies will only issue contracts to farmers with light sand or loamy sand soils, which provide the optimal growing conditions for their preferred varieties, particularly in relation to the dry matter levels of the tubers. The firms also recognise that these light soils have reduced production risks, as the soils do not become water logged enabling access throughout the season.

Thirdly, access to irrigation water is increasingly important, with one crisping company making access to irrigation water a condition of contract. Other companies recognise the importance of irrigation and are steadily increasing the proportion of contract farms with irrigation year on year, with between 50-70% of contract farms now able to irrigate. Nevertheless, none of the processing companies actually recognise the differences in reliability of irrigation water, reflected in licences of right and renewable licences, surface and ground water abstraction sources, or summer and winter abstraction. These are important differences which translate at the farm level into differential access to water in periods of drought and the associated risk of abstraction restrictions. On-farm water storage, the most reliable source of irrigation water, is not, as yet, a condition of contract. The failure of the processing firms to recognise the differential reliability of licence water in their contract, reflects their failure to grasp the complexity of the irrigation issue and their limited knowledge of water issues (see section 5.4 for discussion). The final assessment criterion is purely subjective and reflects the perceptions of the company representative involved in discussions with

the farmer where they assess the attitude of the farmer, willingness to accept advice and ability to work with the processor.

Once the company is convinced of the farmers suitability, the discussions move on to the actual contract. The contract sets out the potato variety, quality specifications and the defects which will lead to the rejection of the crop. The contract price is calculated on the basis of a two-part tariff, which includes a fixed price calculated at the time of contract and a variable price which reflects the market price at the time of delivery, and allows the processor to take advantage of possibly lower seasonal prices. These calculations are fixed, and are not open to negotiation by the farmer. The contract also sets out the delivery details, stating the tonnage and date on which the farmer must produce the potatoes at the factory gate. Finally, a condition of contract stipulates that the farmer must purchase potato seed directly from the processor. This strategy ensures the processor retains some degree of control over the quality of potatoes, as the seed critically influences the incidence of disease in the subsequent crop (see section 5.3.2 for full details) as well as ensuring the processors an additional source of income. The quantity of seed supplied is calculated on the basis of the total tonnage of potatoes the farmer has agreed to produce. The processors adopt a very pessimistic approach and under estimate the yield/acre farmers will achieve, providing more seed than is strictly necessary. In consequence, the majority of farmers exceed expectations and produce in excess of the contract tonnage. The processors appear to be manipulating this situation to their advantage, guaranteeing the production of a set tonnage of potatoes, while at the same time ensuring farmers over produce. This allows them to buy up the surplus material at lower spot market prices in the later stages of the season. On completion of contract negotiations, the processor provides the farmer with a detailed information pack which contains advice on all production issues related to the variety. This includes information on the seed spacing rate, seed bed preparation, application of nitrogen, pesticide and herbicides programmes, when to trigger the first irrigation application,

when to stop irrigation and when to harvest. Only one firm supplements this information with farm visits.

Forward contract production in the processing network enables the processing firms to directly control and manipulate both the on-farm production process and the off-farm exchange process, without incurring any of the risks associated with production and land ownership. The contract undermines the “independence” of the farmer, as production decision making is increasingly dictated by the demands of the processing firm. This is primarily achieved through the specification of strict potato quality criteria, which the processors directly regulate through the provision of detailed information and advice on the best management practices. The processing firm also benefits from what Davis (1980) calls the self-exploitation of the farmer, who willingly coordinates production decision making in line with the processor’s advice, investing greater amounts of his own time and taking greater care, in order to guarantee produce conforms to the quality standards. In consequence, the processing firms succeed in directly and indirectly regulating production and labour time on the farm, and thereby ensure the extraction and transfer of value from the farmer to the processing firm.

In the fresh potato network, forward contracts are very rare and represent only a small fraction of the total issued by the processing firms. Contracts are only used to ensure the production of niche salad potatoes, and no other varieties are actually produced under forward agreements. The pack-house companies have adopted this procurement strategy in response to two critical factors. Firstly, the niche salad varieties are perceived as “difficult” crops to grow, which is further compounded by the strict quality specifications. Secondly, the niche salad potatoes are specialist varieties which serve only one purpose. Thus, if the farmer does not meet the quality specification, the potatoes cannot be used for chipping, baking or processing purposes. In consequence the risks associated with the production of these crops are high, and it is therefore difficult to persuade farmers to grow

them on the free market. Forward contracts are the only way of guaranteeing the production of the crop. The contracts are issued by the pack-house either directly to the farmer, or indirectly through a co-op.

Given the economic and production risks associated with these varieties, the pack-house undertakes a rigorous assessment of the farmer before issuing the contract. Four key factors are examined.

Firstly, and most importantly, only farmers on light sand land are considered, as this free draining soil provides the optimal growing conditions for the crop. Secondly, the farmer must have access to irrigation water, and a predefined quantity of water must be reserved solely for the crop, although again there is no differentiation in terms of the reliability of the water source. Thirdly, the farmer must be an established grower and prove that s/he can consistently produce high quality pre-pack potatoes. Finally, the attitude of the farmer is critical, reflected in their willingness to accept advice and work closely with the pack-house company. Only farmers who satisfy all these criteria are accepted.

The actual contract sets out the potato variety and the associated quality criteria which the crop must conform to. The full contract price is agreed prior to planting, in marked contrast to the two-part tariff used in the processing network. Delivery dates are also stipulated, with the full tonnage delivered to the pack-house on harvest. Finally, the pack-house stipulates, as a condition of contract, that the farmer uses seed supplied by them. This reflects the limited supplies of seed available in these varieties, with a small number of agents controlling supplies in the UK (see section 5.3.2 for full details). Contract negotiations do not mark the end of the pack-house involvement in the production of these varieties. Specialist agronomists and fieldsmen are closely involved with the farmer, providing advice in weekly farm visits throughout the growing season and in part reflects the difficulties of producing specialist varieties, of which the farmers have little experience or knowledge. Thus, close contact is essential to ensure the varieties conform to the

strict quality criteria, and reflects a markedly different approach to the form of contract production in the processing network.

The principal mechanism through which the pack-houses and co-ops indirectly regulate and manipulate farmer production decision making is by controlling the flow of information and advice to farmers. These firms are the gate keepers, or quality regulators of the fresh potato network and are used as a channel through which the supermarkets relay their potato variety and quality specifications. In consequence, these firms play a pivotal role as they relay the information and introduce “new ways of doing things” at the farm level. The pack-houses and co-ops provide detailed production and marketing advice and information to farmers through specialist agronomists and fieldsmen who monitor production throughout the season. This enables them to directly manipulate and shape on-farm production decision making, to ensure farmers not only produce the supermarket preferred varieties, but also that the potatoes actually conform to the quality specifications. By maintaining close contacts with farmers, these firms are able to control production at arms length, without incurring any of the risks associated with production and land ownership. The processing and fresh potato networks have used a combination of direct and indirect measures to regulate and control the production of potatoes, through direct forward contract production and the indirect control of the flow of information and advice to farmers. Both these mechanisms of arms length control enable the processors and pack-houses to regulate production and labour time. This process maximises the transfer of surplus value from the farmer to the off-farm firm, and ensures the production of produce which conforms to their specific variety and quality criteria.

5.3.2 Regulating quality: controlling the supply and quality of seed.

The regulation and control of potato quality is not solely achieved through the manipulation of on-farm production. A second critically important dimension of the work of both the processors and

pack-houses focuses on the quality and supply of potato seed. This enables them to develop specialist potato varieties suited to specific potato purposes, and control the quality of the seed inputs used on the farm. The quality of the seed critically influences the incidence of disease in the subsequent crop (NIAB 1995), and therefore control of this variable reduces one element of uncertainty associated with potato production. In contrast to the 'arms length' control of farm production, the processors and pack-houses have developed close linkages with specialist research and development institutes nationally and internationally, and their own in-house research programmes and specialist seed producing firms.

In the fresh potato network, involvement in seed is solely the preserve of the pack-houses and co-ops, with the supermarkets avoiding direct involvement in the day to day sourcing of new varieties or control of seed quality⁴. The pack-houses supply seed to farmers, either directly as a condition of forward contract production, or through the commercial sales divisions of the company, which enables them to directly control the quality of potato seed inputs at the farm level. Contacts in international and national research and development institutes also enable these firms to respond to new developments initiated by their supermarket customers.

The development of niche salad potato varieties reflects the complex interaction between supermarkets, the pool of preferred suppliers, and their seed sourcing operations. Marketing personnel in one supermarket spotted the potential for a new niche potato product, namely small salad potatoes. Following discussions with the in-house potato technologists, a specification was drawn up and relayed to the pool of defined suppliers, who were asked to find a variety which met this specification and suited UK production conditions. Membership of international research and development institutes enabled these companies to search potential varieties across the globe. One company successfully acquired the commercial rights to the Charlotte variety which conformed to

⁴ Nevertheless, they do play a role critically shaping and manipulating their suppliers most directly through the policing of BS5750 where they demand full knowledge of all chemicals used on the seed.

the supermarket specification, allowing them to control the supply of seed in the UK and by extension, its use on the farm. This example highlights the commercial rewards of maintaining the close linkages across the global food network. The firm capitalised on these close linkages to quickly pin point a variety which matched the supermarket specification. The speed of their response proved critical, enabling them to acquire the commercial rights to the variety before their rivals, and thus control supply within the UK.

In the processing potato network the firms are closely involved in research and development into new potato varieties, reflected in their own in-house programmes and through membership of national and international research institutes, as they continually search for new varieties which will improve the end product. The search for alternative varieties concentrates on two critical factors (i) improving the efficiency of the production process and (ii) improving customer acceptability of the final product. At the international level, these firms have established agreements with the major potato research and development institutes, providing them with access to world-wide developments in potato varieties. At the national level, the processors work through the Potato Processing Association (PPA) which lobbies the PMB to carry out research. This focuses on encouraging research funding into specific problems which occur in production or storage which pose particular problems for the processors (Kirkman *et al* 1991), although these companies have not instigated research into irrigation issues in the past.

The companies also operate individual in-house research programmes, which focus on the sponsorship of commercial trials into specific varieties. For example, one company has responded to the stricter controls on chemical inputs at the farm level by developing a new research and development programme into varieties which require less nitrogen input and are resistant to certain diseases. This company perceives the introduction and extension of controls on chemical usage at the farm level, as a significant threat to their future procurement of potatoes. By instigating

research now, the company is attempting to ensure it has access to varieties which maintain process efficiency and customer acceptability, while at the same time reducing the use of chemical inputs. Once a new variety has proved itself in commercial trials, the processors often acquire the commercial rights to the variety, allowing them sole control of the supply of the seed. This management strategy enables them to develop specific varieties tailored to specific end products, which are commercially confidential and therefore protected from rival processing companies. The processors have extended this control, by developing their own seed growing operations either through direct ownership of land, or contract production with specialist, commercial seed growers.

The regulation of seed quality and supply enables firms in both the fresh and processing potato networks to reduce uncertainty over the quality of potato production by reducing one significant element of variability, namely the incidence of disease in the crop. In addition the research and development programmes into alternative varieties also enables them to continually refine the quality and add value to the end potato product. Processors and pack-houses have developed complex and multiple inter-relationships across the food network to ensure the quality and supply of potatoes. Their inter-relationship with farmers is characterised by direct and indirect forms of regulation which enable the off-farm firms to control and manipulate production at arms length to ensure the quality and supply of potatoes. The process of risk reallocation which underpins the relationship between supermarkets, processors and their pool of 'preferred suppliers', is extended by these firms in their interaction and inter-relationship with farmers at the local level. Balch and Wu (1974) and Ekinsmyth *et al* (1995) postulate that forward contracting enables the parent firm to externalise the risks and uncertainties associated with production for other sub-contracting firms to bear. This analysis of forward contract production confirms this postulated relationship, with the processing firms using the contract agreements to ensure the production and supply of their preferred potato varieties. The contract agreement is used as a vehicle, to transfer the financial, production and environmental risks and uncertainties associated with producing quality potatoes, to

farmers at the local level. In particular, farmers have to bear the consequences of the processors' preference for potato varieties which are vulnerable to drought and water stress, and leaves them more vulnerable to the hazards of low rainfall, drought and abstraction restrictions.

In stark contrast, the relationship with seed input suppliers is markedly different as these subsidiary firms are directly integrated into the parent firm enabling them to develop new varieties. This reflects economies of scale, as the financial risks and uncertainties associated with integrating seed input suppliers, compared to farmers, into the parent company are limited. Exerting control over one or two subsidiary firms is relatively easy and the benefits far outweigh the costs. The parent firm is able to develop varieties specifically suited to their end product while ensuring market confidentiality, thereby enhancing their position in the market place. These processes of direct and indirect regulation and control underline the significant role which companies in the fresh and processing potato networks play in shaping on-farm production decision making and their central role in protecting the environment. .

5.4: Water demand management and the food network: barriers to change.

Action to protect the environment is not unprecedented in the food network, with supermarkets, in particular, responding to the explosion of interest in green issues in the 1980s. One of the most important early initiatives was the introduction of organic vegetables in Safeway in 1984, which was quickly copied by Sainsburys, Tesco, Waitrose, Budgen and Asda (Clunis-Ross 1990). The success of this initiative encouraged Tesco to introduce the Nature's Choice range which attempts to respond to the perceived environmental concerns of customers, without imposing the strict organic production standards of the Soil Association. In the early 1990s however, the supermarkets switched the emphasis away from the development of "niche" environmentally friendly or organic produce, to the extension of uniform environmental standards and controls on all fresh fruit and vegetables. The six main supermarkets, in conjunction with the NFU, have drawn up individual

integrated crop management (ICM) protocols for all fresh fruit and vegetables grown in the UK (see case study 1). This initiative attempts to regulate the use and management of chemical inputs used on all fruit and vegetable crops, to minimise chemical usage and encourage alternative methods such as integrated pest management. As the case study reveals, the ICM initiative is a powerful vehicle for promoting the safety of produce and the environmental friendliness of the production system, with 73% of UK sourced produce sold through Sainsburys produced under ICM conditions (Cunningham 1996). This underlines the power of the supermarkets to instigate change in the food network by forcing farmers to re-evaluate their use of chemicals and consider alternative systems of control. Nevertheless the initiative adopts a very narrow definition of environmental friendliness which focuses solely on the use of chemical inputs, and largely ignores the impact of agriculture on abstraction water and the *in situ* water environment. In fact, irrigation use is only mentioned briefly in the potato ICM protocol in relation to its importance in controlling common scab, and fails to recognise the consequences of meeting this demand for the water environment. The failure to incorporate water and the water environment into this “environmentally friendly” initiative, represents a critically important gap and a combination of factors may have contributed to this. Access to and use of water in the agricultural sector may not be perceived as an environmental problem by off-farm interests. The linkages between summer abstraction for irrigation, decline in river levels and the impact on the *in situ* environment may not be clearly understood by these firms. In fact, misconceptions about agriculture-water-environment issues may reflect their lack of information on the importance of these issues in the UK. Whatever the possible justifications, the failure to address irrigation issues in this document represents an important missed opportunity.

CASE STUDY ONE: INTEGRATED CROP MANAGEMENT PROTOCOLS.

The integrated crop management (ICM) initiative was developed in the early 1990s by the NFU in partnership with ⁵ of the leading UK supermarkets in response to consumer concerns about the environment and the safety of produce. The principal objective of the initiative was to reassure consumers that the UK's food production methods lead to good quality, safe food at affordable prices. In consequence, the partnership has focused on the development of husbandry protocols, or guidelines for individual crops which incorporate the

“..application of scientifically based, good horticultural practice, with particular emphasis on reducing whenever possible the use of chemicals. This involves the promotion of viable integrated crop management (ICM) systems and improved protection of the environment” (Wise 1994, p1).

The first protocols, for fresh carrots and cauliflowers were published in July 1993 and by October 1996 30 different fruit and vegetable crops were covered by individual protocols. The principles of ICM cross a number of husbandry disciplines, including integrated pest management, and attempt to bring together current experience and knowledge of the integration of cultural and chemical methods of pest and disease control. Integrated pest management techniques rely on close crop monitoring using pheromone traps; sticky traps; pest incidence forecasts and disease infectivity models for example, in order to minimise pesticide treatment and avoid blanket treatments. The protocols form the basis of the supply agreement between the grower and the retailer/pack-house (Wise 1994), and in consequence implementation replicates the system of arms length control of on-farm production. Thus, indirect measures of regulation and control are used to ensure production at the farm level conforms to the ICM principles. The pack-houses, which are primarily involved in face to face negotiations with farmers, must ensure all their management and fieldstaff undertake training. Thus they are expected to be fully aware of all the potential risks to crops and must be able to recognise all pests, diseases and weeds as well as beneficial insects, which potentially affect the quality or yield of crops. The monitoring of crops is central to the development of ICM systems, and farmers are therefore expected to adhere to the principles of “self audit” whereby detailed records are maintained on all aspects of the crop, including pest incidence, pesticide applications and crop diaries. These systems of monitoring are policed by the pack-house who verify the system to ensure information is readily available and clearly contributes to the traceability of produce, encapsulated in BS5750.

The protocol for fresh potatoes, published in June 1994, covers all aspects of potato production, from the selection of suitable sites, through rotation and preparation of seed. The major pests and

⁵ CWS Ltd; Gateway; Sainsburys; Safeway; Marks and Spencer; Waitrose. Additional contributions from MAFF; Adas; the PMB; the Fresh Produce Consortium; the Horticultural Development Council; Horticulture Research International; the Institute of Arable Crop Research and relevant fresh produce associations.

diseases which afflict potatoes in seed, production or storage are outlined, and suitable chemical and cultural methods of control documented. Thus, control of potato cyst nematode, one of the most widespread pest problems afflicting potatoes, includes information and advice on site selection, resistant varieties, integrated and chemical methods of control. The document also outlines the health and safety hazards, for both the environment and operators, of all the major chemical applications used to control pests, blight, herbicides and those used for desiccation. Irrigation application is only mentioned in the context of control of common scab, where the document states

“Resistant varieties should be used when possible. Common scab is especially prevalent on light sandy soils, ploughing after grass, or after liming. Irrigation from first tuber initiation is the only method of reducing common scab” (p31).

The ICM initiative represents a powerful tool, through which the supermarkets are attempting to control and regulate the use and management of chemicals on the farm. This is reflected in Sainsbury’s first environmental report published in 1996, where the store underlines its commitment to the principles of ICM and the long term reduction in the use of agro-chemical inputs. To date 73% of UK sourced and 31% of imported fresh fruit and vegetables sold in Sainsburys meet the ICM standards (Cunningham 1996), and they are committed to the further extension of the scheme. The ICM initiative is a central part of Sainsbury’s work to “green food production” encouraging suppliers to maintain wildlife through ponds, woodlands and hedgerows and reduce the use of fertilisers and the risk of ground and surface water pollution.

Evidence to support this line of argument is revealed in the survey, where there is widespread ignorance of irrigation and water environment issues. Although the pack-houses, co-ops and processors all recognise the importance of irrigation application in the production of quality potatoes and meeting their specific standards, there is little awareness, let alone knowledge, of the problems associated with competition for water between industry, agriculture, domestic users and the environment, nor the limited availability of new sources of water to meet future demand. None of the firms were aware of the problems of unreliability of abstraction supply, the threat to agriculture of abstraction restrictions or the environmental justification for controls to maintain river flow levels and protect the environment. In addition, none of the firms had heard of, let alone commented on, local catchment management plans or the regional and national water resource management strategies published by the NRA. Despite this, when provided with a brief summary of the key issues addressed in these documents, all the respondents recognised the important implications for their future procurement of quality potatoes.

This level of ignorance is significant and represents a major impediment to change. The theory of the firm recognises the central importance of access to and use of information in shaping the decision making of firms. Casson (1982) postulates that unequal access to information between firms and at the departmental level, plays a central role shaping their behaviour and response to policy initiatives. The complete ignorance of irrigation and water environment issues among the surveyed personnel may in fact reflect unequal access to information, with some other department holding responsibility for this issue. Nevertheless, this is unlikely as the respondents failed to suggest other departments whose remit may include water issues. In fact, they recognised that their own departments should hold this information. Consequently, the ignorance of water issues simply reflects the (mis)perception of water as a non-issue. This in itself represents a major barrier to change, as the firms are unlikely to instigate new initiatives themselves, or respond positively to

new demand management initiatives introduced by the Environment Agency. Rectifying this situation is a vital first step, ensuring all levels of the food network including the consumer, and not just farmers, are fully aware of the environmental consequences of irrigation use.

Despite this, action by the food network will prove vital to ensure the sustainable development of water resources. The attitude of these firms to the demand management policies set out in Chapter Four will be critically important, as they could play a central role lobbying against certain proposals and thereby undermine the efficiency and efficacy of the policy tools. The analysis in the previous sections demonstrates how the signals emanating from the fresh and processing potato networks, principally in relation to potato variety and quality specifications, conflict with and contradict the work of the Environment Agency in promoting water conservation and demand management on the farm. This is revealed in the proposals, outlined in Chapter Four, to control demand for irrigation water through encouraging farmers to use alternative, drought tolerant crops or crop varieties. The effectiveness of this proposal in practice is limited, as farmers are increasingly restricted to those preferred varieties favoured by the supermarkets and processors. Thus, in the fresh and processing potato networks, the supermarkets and processors limit procurement to between 4-10 varieties, which offer low to moderate tolerance to drought. Consequently, farmers are unlikely to switch to drought tolerant potato varieties which do not appear on the “preferred variety” listings.

The combination of state and market forces of regulation at the agriculture-water interface represents divergent tendencies which push and pull farmers in completely different directions, and only succeed in promoting dissonance at the farm level. Action to promote synergy is vital to ensure the integration of the environment and economy. As noted in Chapter Four, promoting synergy between market and state forces of regulation is no simple task; however reforms introduced by the food network could play a central role promoting the sustainable development of water resources.

Over the short term, the supermarket and processors could promote and reinforce the Environment Agency's message on the wise use of water on the farm, by harnessing their existing resources and organisational involvement with farmers.

The analysis demonstrates how processors, pack-houses and co-ops already play a central role directly and indirectly shaping and manipulating on-farm production through controlling the flow of information and advice to farmers. These forces of regulation could be harnessed to influence the on-farm use and management of irrigation water. For example, the processing firms could stipulate the construction of on-farm reservoirs as a condition of contract; the pack-houses and co-ops could encourage the use of more efficient irrigators through advice and farm visits; while they could all encourage changes to soil and land management practices which improve the soil's moisture retentive capacity. In combination these changes should ensure the more efficient use of existing water resources on the farm.

The switch to alternative drought and scab resistant potato varieties will only be successful if the new varieties are sanctioned by the supermarkets and processors and included on their listings of preferred varieties. To speed up this process, the processors and pack-house companies should be encouraged to take advantage of their extensive involvement in research and development, by instigating research into alternative varieties which combine drought and scab resistance with process efficiency and customer acceptability. In the fresh potato network the quality specifications relating to the appearance of the potato should be relaxed. The presence of common scab which is deemed so critical to the appearance of the potato, does not in any way affect the taste or cookability of the potato, but fuels the demand for water at the farm level by encouraging farmers to instigate an intensive regime of irrigation. Thus the supermarkets could play a central role by relaxing these quality specifications and re-educating consumers by emphasising the costs, both in financial and environmental terms, of producing the "perfect" potato. These changes would have a

significant impact at the farm level reducing the demand for water during the peak periods.

Nevertheless, at the time of interview none of the firms indicated a willingness to change their preferred varieties or relax the associated quality specifications.

Over the medium to long term the companies could play a more proactive role and directly intervene through a number of alternative management strategies to ensure the sustainable use and management of irrigation water. The first management option considers the role of the food network in encouraging the construction of on-farm water storage facilities. Reservoirs provide a reliable supply of water, allowing farmers to guarantee water to a crop throughout the season, while at the same time relieving the stress of summer abstraction on the water environment. Nevertheless, the high capital costs of reservoir construction in some areas of East Anglia and the absence of grant aid means capital constraints dissuade some farmers from investing. To date, none of the firms who issue forward contracts with farmers, differentiate between summer and winter abstraction licences and do not consider reliability of irrigation water a significant issue. However, farmers' access to a reliable supply of irrigation water offers a number of advantages for the off-farm firm, reducing production uncertainty and thereby ensuring the consistent supply of quality potatoes. To further encourage farmers to construct reservoirs firms could provide capital, through loans or joint financing agreements to construct individual or collective reservoirs, for farmers engaged in forward contract production of niche or processing potatoes. All of the firms, including the co-ops, rejected this suggestion outright, claiming there are no precedents for firms, in the processing or fresh potato networks, becoming so closely involved in direct capital investment projects at the farm level. As one company representative argued

“..we don't want to get sucked into that side of the job. At the end of the day we are a food processor, if you start to diversify too much into those sorts of areas you can be swallowed up in something” (Company A)

In contrast, the response to the introduction of a tradable permit system was more favourable, with the companies recognising the benefits of the system and drawing on the parallels with the potato

quota trading system. In the processing network, two firms claimed they would become involved although only indirectly, by acting as a co-ordinator between farmers who want to buy or sell surplus water rights. These companies would not become directly involved, financing the purchase of additional water rights for individual farmers, but would act as a broker. Significantly, both these firms played a similar role in the potato quota trading system. In contrast, the firms in the fresh potato network avoid such direct involvement, and refuse to purchase water rights at the local level. Even the co-ops who play a central role co-ordinating marketing and production advice to farmers, claim they would only play an advisory role liaising between buyers and sellers of water rights, rather than directly purchasing water rights.

In the root vegetable network, three firms claimed they would be actively involved in the tradable permit system as buyers of water rights. As noted earlier, these firms are quite distinctive and already operate a complicated form of water trading, through the rental of land and water rights for specialist root crop and potato production. The involvement of these firms in a tradable permit system as buyers of water rights raises critically important equity considerations, as they have access to non-agricultural dependent sources of income enabling them to out-bid all other participants in a trading system. Although this may conform to the principles of economic efficiency, ensuring water is reallocated from low to high value uses, it raises critical questions of social equity and distributive justice. In particular, this process will further undermine and erode the position of family farmers in the rural economy. These firms all operate highly intensive systems of production, with high levels of dependence on chemical inputs and consequently there is a significant risk of nitrate leaching and pollution of ground and surface water sources. As access to water for irrigation is vital to the extension of this system of production, water trading perpetuates a highly intensive system of production potentially creating far more complicated secondary environmental problems.

The final option considers the re-use of waste water from the processing and packing plants for use as irrigation water on farms. Theoretically if these firms are located within the central potato growing areas, the cost of transporting waste water to farmers could be viable, particularly when incorporating the reduced costs of water treatment. Nevertheless, there are a number of critical problems with such an approach. Firstly, and somewhat surprisingly, the processing factories are located at some distance from the central potato growing areas primarily in urban areas in Scotland, Nottinghamshire, North Humberside and Yorkshire. Thus the costs of transferring waste water in both financial and environmental terms escalate. Secondly, all of the firms claimed the re-use of factory or pack-house water poses significant health and safety risks, with the waste water containing high levels of chemical residues and soil washed from the tubers. Re-using this waste water potentially increases the risk of spreading diseases, such as *Rismania* and consequently these firms do not consider the re-use of their own factory or pack-house waste water a viable option.

Despite the rejection of the direct re-use of their own waste water, the processing and pack-house companies did not reject the option of re-using waste water from other domestic or industrial sources. The processing and pack-house companies argued that so long as national and international standards were adhered to, the re-use of waste water for irrigation would not create any problems or undermine the quality of their produce. However, the supermarkets contradicted this, suggesting that re-use of waste water on the farm would create specific problems for them, as re-use of water contradicts their message on quality. In fact both the supermarkets perceived that the re-use of waste water as irrigation would prove a difficult and complex issue to relay to their customers.

The variable response of firms in both the potato and root vegetable networks to the range of proactive water management options, exposes a number of critical barriers to change. Although the reluctance of some of these firms to become involved in some of the schemes may in part reflect their ignorance of water issues, a number of other factors prevent them from adopting a more

proactive approach. Firstly, the problems associated with access to and use of water in the agricultural sector are perceived by the supermarkets and processors in particular as solely a problem for agriculture. Consequently, these firms argue action to resolve the problems associated with water supply should be undertaken by farmers and the Government. This response reflects the perception that access to water for irrigation is merely a question of improving the supply of water and fails to recognise the complex environmental issues inter-twined in the allocation and regulation of water. Critically, by shifting responsibility to the individual farmer and Government the firms effectively ring fence the farm, accepting no responsibility for the environmental repercussions of producing the “perfect” potato. These risks are firmly reallocated to farms at the local level.

The second critical barrier preventing a proactive approach is the reluctance of firms to increase the variable and capital costs of procuring produce. The system of arms length control enables them to avoid all the financial risks and uncertainties associated with agricultural production. Realignment of this system, accepting a more proactive approach, would represent a major sea change in the form and function of market regulation in the agricultural sector. Some of the reforms encourage off-farm firms to take an equity stake in the production system, increasing their own variable and capital costs of production. The over-whelming desire to avoid these costs explains their reluctance to become involved in schemes such as financing on-farm water storage facilities. Finally the economic power of the supermarkets and processors allows them to define the terms of trade within the food network. The knowledge that other farmers from across the globe are always willing to supply them with the correct quality produce, enables them to define the parameters of their involvement with farmers. Consequently, they are not sympathetic to any production problems encountered by farmers in the UK. To date they have been unwilling to introduce any changes to their own operations, which would alleviate problems at the farm level if there are no obvious benefits to them or their customers. These factors, in combination, explain why off-farm firms have failed to instigate reforms to resolve the particular problems associated with access to and use of

irrigation water. Nevertheless, these problems will have to be overcome as action by off-farm firms is a vital prerequisite to ensure the sustainable development of water resources in the agricultural sector.

CHAPTER SIX

NEGOTIATING THE AGRICULTURE-WATER INTERFACE: FARMERS' INDIVIDUAL AND COLLECTIVE RESPONSE.

The predominant forces of regulatory dissonance at the agriculture-water interface have been identified in Chapters Four and Five. The divergence between market and state forces of regulation is exposed in the competing and conflicting signals emanating from the Environment Agency, and the down-stream food network. The principal objective of this chapter is to assess the impact of these contradictory forces on farmers, and to trace their implications on the use and management of irrigation water and the water environment. The analysis will address three central questions. How do farmers negotiate between and reconcile the competing signals emanating from the market and state forces of regulation? What role do their perceptions and assessments of risk and uncertainty play, as they trade-off the relative costs and benefits associated with engagement with the down-stream food network and the Environment Agency? What are the identifiable gaps in farmer knowledge of water, water rights and the water environment and what are the implications not only for their use and management of irrigation water but also their potential response to demand management policies? In exploring these questions, the analysis is divided into two parts. Drawing on the focused interviews with farmers and their representative organisation, the first part will focus on farmers' interaction and engagement with the down-stream food network. Meanwhile, part two will examine farmers' negotiation and representation with the Environment Agency over access to, and use of, reliable supplies of irrigation water.

The analysis of farmers' incorporation into the quality projects of the down-stream food network will be presented in four sections, with the first section focusing on economic analysis of the value in use (utility) derived from irrigation. This provides insight into the potential financial losses incurred through irrigation withdrawal, and the consequent financial risks and uncertainties incurred through failing to meet the quality specifications. The second section will then provide detailed

analysis of the five key marketing approaches identified among the potato and root vegetable producers, reflecting differential incorporation into the quality projects of the down-stream food network. Access to, and use of, reliable supplies of irrigation water are central to the success of these marketing approaches, and the analysis will identify changes introduced into the management and use of irrigation water in order to reduce their vulnerability to drought and abstraction restrictions. The third section will move on to explore farmer knowledge and perception of water, water rights and the water environment. Drawing on the theory of the firm, and behaviouralist literature on risk and uncertainty, the analysis will assess whether lack of information on water issues plays a role, shaping their use and management of irrigation water and their potential response to demand management policies. The final section will draw out the implications of quality production for the design and implementation of demand management policies, focusing in particular on the role of economic incentive measures. The second part of the chapter will shift the emphasis, and will focus on the interaction between farmers, their representative organisations and the NRA over access to, and use of, reliable supplies of irrigation water. The analysis will address the contention that agriculture-state relations are undergoing a period of change, by examining the response of these different groups to the drought of 1989-92 and its aftermath.

6.1: Negotiating quality at the farm level.

The previous chapter identified the process of risk reallocation as a central dynamic underpinning the inter-relationship between firms and between firms and farmers. This analysis will further develop this line of argument by exploring the contention that farmers' incorporation into the different quality networks critically influence and shape their use and management of irrigation water. This should expose the key forces shaping farmer decision making, and the trade offs calculated between the high prices associated with high quality produce and their ability to consistently meet these quality specifications. Access to, and use of, reliable supplies of irrigation water could prove central to the success of these marketing approaches; however, this has to be balanced against the threat of drought and imposition of abstraction restrictions. Hence, farmers'

perception and assessment of the relative financial, production and environmental risks and uncertainties could play a central role in shaping not only their irrigation decision making, but also their response to demand management policies.

6.1.1: Quality and the financial risks of irrigated production.

The production of potatoes and root vegetables is subject to significant levels of financial risk and uncertainty, with marked inter and intra seasonal fluctuations in the prices received by farmers (see table 5.1 Chapter 5). These price differentials reflect not only variations in the availability of produce but also differences in the quality, with prices ranging from a low of £50/t for general ware potatoes to £150/t for pre-pack supermarket standard potatoes¹ (Morris 1993). Thus, failure to conform with the strict quality specifications can result in significant financial losses of up to £100/t, and is potentially a powerful factor shaping on-farm irrigation decision making. Assessing the impact of these potato price differentials on farmers' use and management of irrigation water will prove critical in understanding their response, or non-response, to demand management policies. One mechanism of evaluating this impact and providing insight into the scale of the financial risks and uncertainties tied up with irrigation use is calculation of the value in use derived from irrigation.

Standard environmental economic analysis postulates that the economic value (utility) derived from irrigation will critically influence farmers' willingness to pay for water and thereby shape their future response to demand management policies (Colby 1989; Gibbons 1986; Rees *et al* 1993). It is assumed farmers, as profit maximisers, will automatically respond to higher water prices by re-evaluating their irrigation use and reallocating water from low to high value crops which should in theory result in a decline in the demand for water. However, in practice the potato price differentials may critically distort this process, and consequently farmers may not respond positively to water

¹ These figures represent the prices for potatoes sold off the field and not those for stored potatoes, which can be significantly higher.

price rises. Although it is acknowledged that value in use figures provide only partial insight into the complex set of factors influencing farmers' perception, valuation and use of irrigation water, it does provide a crude measure of the likely financial losses incurred through irrigation withdrawal (Rees *et al* 1993; Lingard and Gowing 1995; Colby 1989; Gibbons 1986).

One method of calculating the value in use of irrigation water is through farm crop budget analysis, where the value of outputs (productivity gains) generated by water use are compared to the productivity losses resulting from restricted water use. The difference between these two values provides a crude measure of the value in use of irrigation water, and a surrogate measure of farmers' willingness to pay for additional supplies of water. The actual productivity gains and losses attributable to irrigation use can be assessed through analysis of the farm's gross margins, over the short term, when only the variable costs of production are included, and the long term where both fixed and variable costs are added. Hence, gross margin figures are calculated on the basis of current irrigation and land allocation practices to gain a measure of the productivity gains attributable to irrigation, and include three alternative price scenarios for the potato crop of £50/t, £80/t and £150/t to reflect the quality-price differential. The productivity losses resulting from restricted water availability are calculated on the assumption that if irrigation water is unavailable, farmers switch their crop mix to that which yields the highest net returns under dry farming, in this case winter wheat (see appendix B for details of the methods employed). Comparison of these two sets of figures provides an indication of the short term value in use of irrigation water. These figures will prove critical in shaping farmers' response to any unit water price rises, once they have undertaken investment in water storage and irrigation equipment. Including the annualised costs of investment in water storage and irrigation equipment into the calculation provides a long term value in use measure, allowing estimation of the demand for new abstraction authorisations.

Table 6.1 reveals the major financial losses incurred over the short term if farmers are forced to switch to the dry farming option. Under the £50 potato price scenario, a total of 18 farms or 40% of

the sample incur negative values indicating irrigated production is uneconomic when forced to accept such low potato prices, and these farms would be better off moving out of irrigation to the dry farming option. Detailed analysis of these aggregate figures reveals marked distinctions between farms, with 13 located in the Bain-Witham catchment, where potatoes are the sole irrigated crop. Of no less significance, these farms are all small family farms producing less than 25 hectares of potatoes, with access to less than 30 megalitres of water. In contrast only three farms in the Lark and two in the Thet-Little Ouse incur negative values, reflecting the fact irrigation is used on a number of high value vegetable crops, thereby insulating them from the impact of severe potato price fluctuations.

When excluding the negative and zero values, the farms incur an average loss of £68,513. However this figure masks the wide variation in outcomes with losses ranging from a low of £3,294 to a high of £428,358. Consequently, the average figures must be interpreted with extreme caution. In fact, detailed scrutiny of these figures reveals that the losses in the £50-100,000 range are incurred by those farms producing in excess of 100 hectares of potatoes, while those farms in the £100-500,000 range combine large areas of potato with production of other outdoor vegetable crops.

Consequently, the size of the total irrigated area will play a significant role determining the scale of the losses incurred switching to the dry farming option. Examination of the losses incurred per irrigated hectare and per authorised megalitre, which average £981.18 (a range of between £57.34 and £6,900) and £1,458 (a range of £31.88 and £4,600) respectively, show that the losses are greatly in excess of the current authorised abstraction charges.

As anticipated, the losses incurred under the £80 potato price scenario rise to an average of £71,775 ranging between £519 and £54,643 with a 13.8% reduction in the total gross margin incurred by switching to the dry farming option. Significantly, under this scenario no farms incur negative values, although a total of 10 farms, or 22% of the sample, incur losses of under £10,000. The long term viability of irrigation on these farms will prove questionable when including the annualised

Part A: Aggregate loss	£50	£80	£150
Irrigated gross margin	18902885.14	20263357.6	26229919.0
Wheat gross margin	17464107.02	17464107.0	17464107.0
Difference	1438778.00	2799250.0	8765845.0
% change	7.6%	13.8%	33%
n*	39	39	39
Average	31,972.84	62,205.50	224,765.0
Average excluding negative/ zero values	68,513.23	71,775.60	
Part B: Distribution of aggregate loss (firm count)	£50	£80	£150
negative	18	0	0
Under £10,000	3	10	4
£10,000 - £30,000	2	5	2
£30,000 - £50,000	5	6	7
£50,000 - £100,000	7	8	7
£100,000 - £500,000	4	8	15
£500,000 - £1 million	-	2	4
Part C: Distribution of loss per irrigated hectare	£50	£80	£150
negative	18	-	-
Under £500	5	15	-
£500 - £1000	9	8	6
£1000 - £2500	1	9	18
£2500 - £5000	4	5	12
£5000 - £10000	2	2	3
Average loss	£457.88	£1209	£2210
Average loss excluding negative/ zero values	£981.18	£1396	£2550
Part D: Distribution of loss per authorised megalitre	£50	£80	£150
negative	18	-	-
under £50	2	4	-
£50 - £250	6	6	-
£250 - £500	4	13	6
£500 - £1000	2	5	13
£1000 - £1500	4	5	4
£1500 - £2000	1	-	4
£2000 - £2500	1	2	3
£2500 - £5000	-	2	6
£5000 - £7500	-	-	1
£7500 - £10000	1	2	2
Average loss	£680.50	£1094.60	£1739.98
Average loss excluding negative/ zero values	£1458.40	£1263.0	£2007.67

Table 6.1: Short term gross margin losses

*Six farms who ended irrigation in the aftermath of the 1989-92 drought are excluded from the analysis, only potato and root vegetable growers included.

costs of irrigation investment into the calculation. In fact any increase in the variable or fixed costs of production, could render irrigated production on these 10 farms uneconomic. In marked contrast, under the £150 potato price scenario the sample farms experience a 33% reduction in their gross margins when switching to the dry farming option. This potato price scenario represents a conservative assessment of the price paid for supermarket standard pre-pack potatoes, with prices for particular varieties often in excess of this figure. On average the farms experience a loss of £224,765 by switching to the dry farming option; however this disguises the wide variation in values with figures ranging from a low of £9,826 to a high of £382,461. In fact a total of 15 farms incur losses of between £100,000 and £500,000, and examining these figures in combination with the losses incurred per irrigated hectare and per authorised megalitre, reveals the losses are greatly in excess of the current unit cost of abstraction water.

The short term gross margin analysis gives an indication of the financial risks associated with irrigated production. The price differentials associated with the different potato quality networks have a marked impact on the farms gross margins, and underlines the financial importance of irrigation to ensure quality. Failure to meet the quality specifications associated with the supermarket network, means farmers are excluded from the high potato prices associated with quality pre-pack production. In consequence, farmers are forced to accept much lower prices as they sell their produce on the general ware market, where prices average £50/t. Under this low price scenario, irrigated production is uneconomic for a total of 18 farms and they would be better off financially switching to the dry farming option. The farms may be able to absorb such price shocks for one season, but if they are forced to accept these low prices year on year, the long term viability of irrigated production is questionable. This is reinforced under the £80 potato price scenario where, tracking the response of these 18 farms, analysis reveals 10 farms where the financial viability of irrigation is low. These farms incur losses of less than £10,000 and are vulnerable to increases in the variable or fixed costs of production, which could render irrigation uneconomic.

The long term gross margin analysis includes in the calculation the annualised costs of irrigation equipment and water storage, to provide a longer term value in use of irrigation, and an alternative indication of the financial risks associated with production. The costs of irrigation equipment and, where appropriate, water storage facilities are deducted from the irrigated gross margin and then compared to the gross margin figures calculated under the dry farming option (see Appendix B, Parts 1 and 2 for details of the methods employed). As expected, when the annualised costs of irrigation and storage are included in the calculation, the size of the losses incurred in moving to dry farming are smaller than those revealed in the short term gross margin analysis (see table 6.2). Predictably, the number of farmers incurring negative values under both the £50 and £80 price scenario increases to 24 and 10 farms respectively. Clearly, irrigated production on these farms, under both the low and medium price scenarios, is uneconomic, and the farmers would increase their net returns over time by shifting out of irrigation into dry farming. The continued viability of farms incurring losses of under £5000 in both the £50 and £80 potato price scenario is questionable, when faced with the replacement or repair of irrigation equipment. Close examination of these aggregate figures reveals that of the farmers incurring negative or zero values under the £50 and £80 scenario, the annualised cost of irrigation investment on eight farms is in excess of £50,000. High levels of investment in irrigation including construction of reservoirs, sophisticated water transfer schemes and a low ratio of hectares per irrigator, translates into £500,000 - £1 million actually invested. These farmers must achieve the high prices of £150 /t, and above, in order to make a return on their investment. This is an important factor influencing their use and management of irrigation water over the short term, and could also potentially distort their response to alternative, demand management policies.

Part A: Aggregate loss	£50	£80	£150
Irrigated gross margin	18902885.14	20263357.6	26229919.00
Wheat gross margin	17464107.02	17464107.0	17464107.00
Annualised irrigation capital cost	1366043.60	1366045.60	1366043.60
Difference	72732.40	1433204.40	7,399,769.00
% change	0.38%	7.07%	28%
n*	39	39	39
Average loss	£1,864.9	£36,748.0	£189,737
Average loss excluding negative / zero values	£4,848.80	£49,420.84	
Part B: Distribution of aggregate loss (firm count)	£50	£80	£150
negative	24	10	-
under £500	1	1	-
£500 - £1000	-	2	-
£1000 - £5000	1	3	2
£5000 - £10000	-	2	2
£10000 - £25000	2	4	2
£25000 - £50000	8	3	7
£50000 - £100000	-	10	7
£100000 - £500000	3	4	16
£500000 - £1 million	-	-	1
Part C: Distribution of loss per authorised megalitre	£50	£80	£150
negative	24	10	-
under £250	6	10	5
£250 - £500	4	8	7
£500 - £750	-	4	10
£750 - £1000	2	2	1
£1000 - £1500	-	1	5
£1500 - £3000	-	1	6
£3000 - £6000	1	1	2
£6000 - £10000	2	2	3
Average loss	£212.17	£609.59	£1241
Average loss excluding negative / zero values	£636.52	£945.91	£1432
Part D: Distribution of loss per irrigated hectare	£50	£80	£150
negative	24	10	-
under £50	1	4	-
£50 - £100	-	5	-
£100 - £500	4	5	-
£500 - £1000	6	5	8
£1000 - £5000	3	9	30
£5000 - £10000	1	1	1
Average loss	£106.60	£462	£1469
Average loss excluding negative/ zero values	£320.0	£717	£1695

Table 6.2: The long term gross margin losses (7% real cost of capital)

*Six farms who ended irrigation in the aftermath of the 1989-92 drought are excluded from the analysis, only potato and root vegetable growers included.

The losses incurred by the remaining farmers are still significant, with three farms in the £50 price scenario incurring losses in excess of £50,000. These farms grow potatoes in combination with other high value vegetable crops, and are therefore insulated from the impact of fluctuating potato prices. Under the £80 price scenario, the number of farms incurring losses in excess of £50,000 rises to 14 farms and 24 under the £150 price scenario. Clearly, with such high rates of return on investment, farmers incurring losses in excess of £50,000 would be largely unresponsive to increases in the unit cost of irrigation water.

The incorporation of the price differentials associated with the different potato quality networks reveals the scale of the potential financial losses associated with failure to conform to the quality specifications. Analysis of the short- and long-term value in use of irrigation water demonstrates the significant financial losses some farmers would incur if irrigation water is withdrawn. It also reveals that irrigation is already unviable on other farms, particularly when the annualised costs of irrigation investment are included in the calculation. Consequently, it is likely that farmers will display a range of responses to demand management policies reflecting their differential levels of investment in irrigation, and dependency on achieving high premiums for irrigated produce.

6.1.2. Interaction with the down-stream food network: The marketing of irrigated produce.

The marketing of potatoes and vegetables is a complex and dynamic arena of decision making, with a range of alternative options open to farmers. The key factors which differentiate these various marketing options are the produce quality specifications and the associated price premiums. Farmers' access to, and engagement with, these different quality networks depend on their ability and willingness to incorporate the quality specifications into their own crop management practices, which in turn is critically determined by their access to, and use of, reliable supplies of irrigation water. Chapter Five demonstrated how these different quality networks impose differential levels of production and financial risk on farmers. It is therefore critical to focus on how farmers respond

to, and manage, these risks as they develop their produce marketing strategies, and the implications for their use and management of irrigation water.

Five distinctive marketing approaches were identified among the 45 potato and root vegetable producers, reflecting differential levels of incorporation and engagement with the quality “projects” of the down-stream food network. The five marketing strategies include production for the open market; production under forward contract agreements combined with the open market; production under forward contract agreements only; resource sub-contracting and finally those who have disengaged from irrigated production. Access to, and use of, reliable supplies of irrigation water are vital to the success of these marketing strategies, and farmers are introducing a range of management practices to reduce their vulnerability to the hazards of drought and low rainfall. The analysis in this section will concentrate on the detailed scrutiny of the first three marketing approaches, leaving the analysis of resource sub-contracting to section 6.1.3. The complex and dynamic processes of interaction are explored through the use of case studies, which are chosen to represent the range of actor strategies identifiable among the sub-sample of 35 potato and vegetable producers.

(i) Marketing through the fresh potato network.

Marketing of potatoes on the open market potentially incurs significant levels of financial risk and uncertainty, as farmers have no guaranteed market outlet or price for their produce at the beginning of the season. Although this strategy pays off in periods of under supply when the prices are high, farmers also have to absorb the extreme low prices, which accompany periods of over production. In total 14 farms sell their produce on the open market, either through merchants or co-ops, and are involved in two distinctive circuits of the fresh potato network. The first group of five farms produce pre-pack potatoes in line with the supermarket quality specifications, which are then sold through a co-op; the second group, a total of nine farms, produce early potatoes which are sold directly through merchants. The quality specifications associated with production for these markets

are markedly different and impose distinctive production and financial risks on farmers.

Unsurprisingly, access to, and use of, reliable supplies of irrigation water are key factors which differentiate these two groups, with significant differences in their total licensed quantity of water.

For the first group, quality is the key to the success of their marketing strategy, as they argue that they will easily find an outlet for produce if their produce conforms to the highest quality specifications; as Mr F outlines

“If you grow a lot of rubbish then nobody will want it. If you grow excellent stuff, the market is going to want it, it doesn’t matter if you are on contract or not, either you are going to get a small percentage taken out, or none at all and a price which reflects the market” (Mr F. p3)

Central to this marketing approach is the farmers’ interaction with the co-op representatives who, as demonstrated in Chapter Five, are the gate keepers to the pre-pack quality network. In fact the farmers closely co-ordinate production in line with this advice and information on the variety and quality specifications are incorporated into their own management practices. A combination of Desiree, Cara, Esteema and Maris Piper varieties are grown, which offer variable resistance to drought and common scab, and are designated to meet the baking potato quality specifications. The degree to which farmers co-ordinate production in line with the co-op advice is demonstrated in case study one.

Farm case study one concerns farmer A. who invested in irrigation in the early 1980s in order to introduce potatoes into the rotation. Initially, the licence application confined irrigation to a small area of the farm and sufficient water to irrigate just the potato crop. However, the borehole investigations revealed significant quantities of water and in consequence the farmer extended the licence application to 318 megalitres to cover the entire farm, enabling irrigation of sugar beet, cereals and grassland and invested £120,000 in the irrigation system.

The production and marketing of the potato crop are closely inter-twined and the farmer relies heavily on the advice of the co-op, through which he sells the entire crop. Although there is no agreement or contract price for produce agreed at the beginning of the season, the co-op does agree to market the crop, whatever its quality, and the farmer is therefore not involved in complex negotiations with other off-farm firms. This is a major advantage as the farmer perceives that he is able to take advantage of the wide set of market outlets and contacts developed by the co-op staff, and thereby gain access to the high prices associated with the supermarkets. The farmer closely adheres to the advice of

the co-op, who suggest the market sector and potato variety which is most suitable for production on his farm. Thus the farmer produces 33.2 hectares of potatoes designated for the pre-pack baking potato market. Quality is critical in gaining access to and maintaining his position in this market. The quality specifications are relayed by the co-op staff who tailor their production advice in order to ensure the end product conforms to their specific customer requirements. The production advice relates not only to the potato variety but also includes detailed information on potato seed type; seed spacing rate; planting dates; fertiliser and pesticide programmes; irrigation application and harvesting dates. The farmer closely incorporates this information into management of the crop to ensure production conforms to the quality specifications. The farmer relies heavily on this advice and recognises the co-op does 'hold his hand', and although he compromises some of his own independence he does succeed in insuring produce precisely conforms to what the market demands.

Central to the success of this approach is irrigation, as the light sand land is highly susceptible to common scab. Thus, the farmer closely monitors the crop to ensure irrigation commences as soon as tuber initiation starts. The SMD is maintained at a constant 15mm below field capacity for a six week period, across the entire potato area in order to prevent the onset of common scab problems. Thereafter, the SMD increases so by the end of the season it has crept up to 40mm, when irrigation is used to maintain crop growth, ensure an even pattern of growth and improve tuber size. Once the tubers meet the size specification, irrigation stops and the crop is burnt off and eventually harvested. The farmer recognises irrigation is central to the success of this marketing strategy, enabling him consistently to produce tubers of a uniform size and shape which are free from common scab. This farmer has instigated an intensive regime of irrigation, using 4 spray irrigators to ensure water is applied immediately the crop requires it. In addition up to 30% of the licensed water is used in the 6 week period following tuber initiation, solely to improve the appearance of the potato and prevent the onset of common scab. The farmer argues without irrigation water he would not contemplate producing potatoes, as he would be unable to meet the quality specifications associated with the pre-pack market, as he explains

"..you must go for a scab control programme, that is the absolute number one priority with potatoes. If you don't, you might as well throw them away..."(p5).

Potatoes are not the only irrigated crop and given the size of the licence, Mr A has been able to utilise the remaining water on other low value crops, primarily sugar beet, cereals and grassland in order to increase yields and the stocking rate on the beef herd. Nevertheless, this system dramatically altered in the drought years of 1989-92, when abstraction restrictions were imposed. This was the first time Mr A experienced restrictions on his abstraction and he was forced to radically re-evaluate his water use and establish a new set of water priority crops. This culminated in the reallocation of water from the low value cereal and sugar beet crops to the reservation of water solely for the potato crop. Thus, even when a 50% abstraction restriction is imposed, Mr A ensures he has sufficient water to operate the intensive irrigation regime on the potato crop, and thereby ensure they conform to the quality specifications.

By combining production and marketing advice to the farmer, the co-op succeeds in indirectly manipulating on-farm production decision making, regulating both production and labour time to control the quality of produce. Although the "independence" of the farmer is to some extent

undermined by these processes of indirect market regulation, there are also advantages as incorporating the advice enables the farmer to reduce uncertainty over production of quality produce. Farmers adopting this approach, exemplified by farmer A, have been effectively persuaded of the importance of quality in marketing potatoes, and consequently enrolled into the quality projects of the down-stream food network through their interaction with co-op staff. In reality, their wholesale commitment to producing quality pre-pack potatoes is not unsurprising given the price premiums, and they willingly compromise their “independence” in order to guarantee these premiums and thereby insulate themselves from the extreme price volatility associated with the general ware potato market.

The critical dimension of quality for pre-pack potatoes is recognised by the farmers as the skin finish and appearance of the tubers. In fact the absence of common scab is perceived as essential to the marketability of the potatoes, as failure to conform to this specification can lead to a major reduction in the value of the crop. In consequence, all these farmers recognise the vital role of irrigation and they all operate intensive regimes of irrigation. The case study reveals how carefully farmers monitor their potato crops, in order to trigger irrigation at the onset of tuber initiation. Up to 30-40% of the total licensed water quantity is used in this six week period without any additional benefits to the crop, and is the most important factor influencing quality, as farmer G explains

“Well, water is vital. I would not contemplate growing potatoes in today’s market without adequate irrigation.... Potatoes are a high value crop, you spend a lot of money on potatoes before you harvest a ton. If you don’t produce the right tonnes per acre, at the right quality, you lose a lot of money.” (Mr G p38)

The implementation of an intensive irrigation regime is dependent on access to water resources, and these farmers hold licences for an average of 257.47 megalitres, which is the highest average licensed quantity in the sample. 100% of the water is reserved solely for the potato crop and no other crops receive irrigation. This reflects a significant shift in the management and use of irrigation water which occurred during the drought of 1989-92. The changes introduced by farmer A in case study one are reflective of a wider reappraisal of irrigation use at the farm level which

culminated in all five farms ending irrigation of low value cereal, grass and sugar beet crops in the aftermath of the 1989-92 drought. Water is now reserved solely for the potato crop, to ensure sufficient water to implement the irrigation regime when 50% abstraction restrictions are imposed. This reallocation of water from low to high value crops underlines how the increasing emphasis on produce quality has led to a revaluation of access to water resources. By reserving water solely for their potato crop these farmers have sufficient water to meet the pre-pack quality specifications.

Surprisingly, given the risk of unreliability of abstraction supply and the associated financial losses which these farmers could potentially incur, only three farms have invested in on-farm water storage. Investment in water storage represents an insurance against the financial losses incurred in a drought period, as reservoirs are a reliable supply of water. The wide variation in reservoir construction costs exerts a powerful influence, as two of the three farms are in the Lincolnshire catchment, and are able to take advantage of the cheap reservoir sites. Despite this, of the three farms who have constructed reservoirs, two were built in the aftermath of the 1989-92 drought, and one of these was in the Lark catchment. The financial benefits associated with reservoir construction clearly over-ride the high construction costs, as farmers trade off the financial losses associated with poor quality produce. This is revealed in case study two, where the farmer invested in a reservoir after incurring losses of £100,000 through failing to meet the pre-pack quality specifications.

The farm second case study involves farmer B, who in the aftermath of the 1989-92 drought constructed a reservoir in order to guarantee irrigation to his potato crop. This 440 hectare farm, which is wholly owned, produces 76 hectares of potatoes which are sold on the open market through a co-op. A combination of Cara, King Edward and Esteema are grown specifically for the pre-pack market. Irrigation is vital to the success of this marketing strategy and the farmer operates an intensive regime of irrigation. Mr B holds a summer licence to abstract 104 megalitres from groundwater sources, which is sufficient to meet this demand. However, in 1990 a 100% abstraction restriction was imposed midway through the season and resulted in Mr B producing a crop of potatoes suffering from low yields and poor skin finish which failed to meet the pre-pack quality specifications. As a result Mr B incurred a financial loss of £100,000 as the crop was sold as stock feed for a markedly lower price. As a direct consequence of this experience Mr B invested £140,000 in the construction of a rubber lined reservoir with a capacity of 68 megalitres. This provides a guaranteed supply of water which will ensure irrigation of the potato crop if

abstraction restrictions are imposed. With the two sources of water Mr B has a choice of using cheap winter water or relatively expensive summer water. These differences in unit water charges do not impinge on Mr B's actual irrigation decision making, as he uses the summer water first, until restrictions are imposed and thereafter switches to use the reservoir water. This strategy ensures Mr B can guarantee irrigation of his potato crop throughout the season, by reserving reservoir water for the later stages of the season.

Investment in water storage enabled farmer B to reduce uncertainty over the production of quality pre-pack potatoes, as he is able to guarantee sufficient water to operate the intensive irrigation regime. Comparison of the annualised cost of this investment (£16,694) against the actual short term losses incurred through the withdrawal of irrigation water (£282,807) underlines the significant financial advantages attached to investment in storage, with the financial benefits far outweighing the costs.

The cost of investing in storage represents only a fraction of the total capital investment tied up in irrigation, with the total annualised cost averaging £51,000 across the five farms ranging from a low of £19,000 to a high of £118,000. These figures are high as the farmers have adopted a strategy whereby the ratio of hectares to irrigators is low, with investment in 3-4 irrigators rather than 1-2 to ensure water is applied immediately the crop needs it. Thus, it is critical for these farmers to make a return on investment, as under both the £50 and £80 price scenarios in the long term gross margin analysis 4 and 2 farms respectively incur negative values, and only make a return on investment under the £150 potato price scenario. This underlines the critical financial importance of achieving the premium potato prices, and represents a major factor shaping not only farmers' irrigation management but also their potential response to demand management policies.

The overriding objective shaping the management and use of irrigation water on these farms is the production of potatoes which conform to the pre-pack quality specifications. Through incorporating the quality projects of the pre-pack fresh potato network so closely into on-farm management practices, these farmers are attempting to consistently achieve the high premium prices. Although significant production risks are associated with this approach, farmers have responded by acquiring

large abstraction licences and investing heavily in irrigation, in order to avoid the risks associated with unreliable supplies of abstraction water and abstraction restrictions. Access to, and use of, reliable supplies of irrigation water are central to the success of this marketing approach, and the farmers have introduced a number of changes in order to reduce their vulnerability to drought, low rainfall and abstraction restrictions. All the farmers have reallocated water from low value cereal and sugar beet crops, to ensure sufficient is available for the potato crop if abstraction restrictions are imposed and three farms have invested in water storage. More far reaching changes, such as the introduction of drought tolerant potato varieties or movement to incorporation in less exacting quality networks, have been avoided. These farmers are unwilling to compromise on quality, whatever the economic or environmental costs.

The second group of farmers to market their produce through the open market are involved in a markedly different network of quality. These nine farmers, all in the Bain-Witham catchment study area, produce potatoes for the early market in an attempt to take advantage of the high premium prices associated with early potatoes. The quality specifications associated with early potato production are distinctly different from those associated with the pre-pack quality network, and impose different levels of production risk on farmers. In fact, by focusing production on the early market these farmers avoid the risks associated with drought as the crop is harvested by the end of June, early July, before the normal onset of abstraction restrictions. These farmers are not involved in complex interactions and negotiations with the down-stream food network, as the potatoes are sold directly to merchants and they receive little specialist advice or information related to the production or marketing of the crop. Once the crop is harvested, the farmers contact a number of local merchants to compare prices and the potatoes are sold to the merchant quoting the best price on the day.

This relatively simple marketing approach means the farmers must take advantage of the high prices in the early part of the season, as thereafter the value of the early varieties falls off dramatically.

The area of potato production averages 13 hectares, the smallest area under production among all producers, and allows the farmers to rely on unpaid family labour and minimal investment in specialist equipment to produce and harvest the crop. This is reflected in their investment in irrigation where they use second hand machinery or equipment which dates from the 1960's. In consequence, the annualised cost of investment is low with an average figure of £1405; obviously the economic viability of continued irrigation will be brought into question when these farmers have to finance equipment replacement or repair.

Access to and use of irrigation water is an important element in the production of the early crop, although it is used to increase the yield in the later growth stages rather than to improve the skin finish. In fact these farmers have insufficient water to instigate an intensive irrigation regime to ensure produce conforms to the quality specifications designed for pre-pack potatoes. Even though the actual area of potatoes is small, the farms have limited water available with the total licensed quantity of water on these farms averaging 23.5 megalitres, ranging as low as 4.5 megalitres. Despite this, five farms have constructed winter storage facilities, all of them taking advantage of gravel company deals. Thus the actual cost of investment is low, and when cross questioned these farmers admitted that they would not have proceeded if they had to pay the full cost of reservoir construction themselves.

The farmers involved in the fresh potato network all share a common perception of the financial risks and uncertainties associated with potato production. They all attempt, in different ways, to guard against potato price volatility by producing high quality or niche products which attract a premium price. Despite these broad similarities, the two groups of farmers are incorporated into distinctly different networks of quality, with one group of farmers involved in the pre-pack fresh potato network, while the second group produces and markets early new potatoes. Access to, and use of, reliable supplies of irrigation water is a key factor which differentiates these two groups. Farmers producing potatoes which conform to the pre-pack quality specifications hold abstraction

licences in excess of 100 megalitres of water and have invested heavily in irrigation equipment and storage. This represents a highly capital and water intensive system of production to ensure produce conforms to the strict pre-pack quality specifications, which in turn guarantees the premium prices.

In marked contrast, the second group of farmers have adopted a less capital intensive system of production, utilising unpaid family labour and second-hand equipment to produce early new potatoes, in order to reduce their vulnerability to potato price fluctuations. The development of this marketing strategy has been influenced by access to water resources, as these farmers have insufficient water to operate an intensive irrigation regime. Although production for the early market succeeds in avoiding the financial risks associated with unreliability of abstraction supply, the long term viability of continued potato production on the farm is questionable as the dual processes of concentration and scale enlargement continually squeeze small potato farmers out of production (Bates *et al* 1996). This is revealed in the gross margin analysis where the losses incurred in the short term analysis range from £6,288 to £59,423 under the £150 potato price scenario, but these figures decline markedly in the long term calculations. Consequently, the long term viability of irrigated potato production on these farms is questionable as they are vulnerable to increases in the variable and fixed costs of production. The response of these two groups of farmers to the implementation of demand management policies is potentially markedly different, as they will be critically influenced by their own perception and assessment of the relative risks and uncertainties associated with irrigation and the economic value of irrigation use.

(ii) Dual marketing strategy: Incorporation into the fresh and processing potato networks.

The second marketing approach identified in the sample involves a complex, dual marketing strategy in which nine farmers produce processing potatoes under forward contract agreements as well as pre-pack potatoes for sale on the open market. This dual marketing approach reflects farmers assessment of the relative financial risks associated with production for the open market. The development of this approach is also critically influenced by their access to, and use of,

reliable supplies of irrigation water. This marketing approach therefore represents an attempt, by the farmers themselves, to spread the financial risks associated with potato production as well as reduce their vulnerability to drought and unreliability of abstraction supply.

Farmers involved in this dual marketing approach have allocated between 40-60% of their total potato area to forward contract production of crisp and chip varieties. The total potato area averages 67.4 hectares, and the remaining area is sold through the fresh potato network with three farms selling to local merchants while 6 use a co-op to market their pre-pack baking quality potatoes. The farmers pursuing this dual marketing approach are involved in distinctly different quality networks, which impose differential levels of production and financial risk and uncertainty. The farmers argue that by producing processing potatoes under forward contract agreements they reduce the level of financial risk and uncertainty associated with production, as the agreements enable the farmers to ensure a financial return on a set area of production at the beginning of the season. As Mr I argues

“Because Records (a crisping potato variety) are a fixed price contract, you know exactly what price you will get from the onset. Potato prices can fluctuate horrendously, and it is nice to know that 50% of them are at a fixed price which you are happy with, you know the return per acre and that is removing uncertainty” (Mr I p5).

By incorporating forward contract agreements into their farm management strategies these farmers guarantee a return on investment, and ensure against the extreme low prices which can afflict the open market. Nevertheless, these financial factors are not the sole influence, as the farmers are critically aware of the implications for the on-farm use and management of irrigation water. The quality specifications, in particular those related to the appearance and skin finish of the potato, have played a central role. These farmers are unable to consistently produce pre-pack potatoes on their entire potato area, as they have insufficient water to control common scab. Although the licensed quantity of water available to these farms averages 162.12 megalitres and four farms, all in the Bain-Witham, have invested in water storage, these farmers are still unable to irrigate on the entire potato area in line with a strict common scab irrigation programme. Consequently they are

vulnerable to significant financial losses by marketing produce which fails to conform to the pre-pack quality specifications. Farmers therefore have to trade off the relative financial, production and environmental risks and uncertainties associated with involvement with both the fresh and processing potato networks in order to formulate effective and efficient systems suited to their particular needs and resources, as revealed in case study three.

The third farm case study involves farmer C who owns a 720 hectare light sandland farm and grows a combination of pre-pack and processing chip potatoes. Mr C holds 3 irrigation licences to abstract, from both surface and ground water sources, a total of 87.91 megalitres in the summer months. He has invested £50,000 in irrigation equipment, installing an underground mains pipeline which covers the entire farm and 3 hose reel irrigators. A total of 51 hectares of potatoes are under production and 50% of the area is committed, under forward contract agreements, to Russet Burbank, a processing chip variety while the remaining area is under production of Desiree, Esteema and Santae varieties which are all designated for the pre-pack baking potato market. These varieties are all marketed through a co-op and Mr C has no direct contact with the processing firm, as all negotiations are conducted through the co-op staff.

The processing chip variety was introduced as a direct consequence of quality problems encountered during the drought of 1989-92 when Mr C was unable to consistently conform to the pre-pack quality specifications. Mr C recognised he was unable to consistently meet the skin finish quality specifications, as he had insufficient water to operate a strict scab control programme and ensure sufficient water for the later stages of the season. The introduction of the processing variety, alleviates the pressure on Mr C's water resources, as the specifications in relation to skin finish are not so strict. Therefore Mr C is able to concentrate irrigation in the early stages of the season on the pre-pack varieties. The development of this dual marketing approach is a direct consequence of Mr C's inability to consistently conform to the pre-pack quality specifications on the entire potato area and his unwillingness to incur the associated financial losses. The introduction of the processing variety succeeds in reducing his vulnerability to the problem of common scab, while at the same time providing a fixed income from the crop thereby insuring a fixed return on his investment.

As case study three demonstrates quality is a central factor shaping the development of this produce marketing strategy as farmers recognise the financial importance of consistently meeting the specifications laid down by the off-farm firms.

Investment in irrigation is high with the annualised cost averaging £55,088 for all nine farms, but this average conceals marked differences. In fact, the six farms which combine processing with pre-pack potatoes average an annualised investment cost of £79,187 compared to £6,890 for the

remaining three farms. Ensuring a return on investment is therefore a significant factor influencing decision making on these capital and water intensive farms, as low quality incurs low prices and potentially significant financial losses. This is revealed under the £50 potato price scenario in the long term gross margin analysis, where all six farms incur negative values.

Access to, and use of, reliable supplies of irrigation water is a key factor influencing the development of this marketing approach, and in fact three farms, all in the Thet-Little Ouse catchment engaged in the production of contract processing potatoes in the aftermath of the 1989-92 drought. These farmers were unable to guarantee irrigation of their entire area of pre-pack potatoes and consequently incurred significant financial losses as the produce failed to conform to the pre-pack quality specifications. The farmers were unwilling to incur these financial losses again, as individually they lost between £10-20,000 on their potato crop. Despite this, they were unwilling to invest in on-farm water storage, which may be regarded as somewhat surprising as storage is a reliable supply of water. However, a combination of factors provides an explanation for this seemingly unexpected response. Firstly, construction of on-farm water storage facilities on the flat sand land of the Thet-Little Ouse catchment is a major capital investment project, costing in excess of £150,000. Secondly, uncertainty over the future of the potato market and in particular potato prices is significant, primarily as a result of Government reform of the PMB. Consequently, these farmers are unwilling to invest in any major capital project and increase their level of borrowing, until they have a clearer picture of the future shape of the market. This risk averse strategy reflects farmers' unwillingness to increase their vulnerability to future price shocks and the attendant financial losses, and is justified by farmer D in case study four.

The fourth farm case study involves Mr D, a tenant farmer on 259 hectares in the heart of the Brecklands, who grows a total of 97 hectares of potatoes with the remaining area taken up by sugar beet and cereal crops. In total Mr D holds abstraction licences for 193.18 megalitres of water from surface and ground water sources and has invested £150,000 in actual irrigation equipment. Mr D produces a number of different potato varieties, with 50% of the total area under Russet Burbank a processing chip variety, while the remaining area is taken up in pre-pack varieties including Esteema and Romano and the entire crop is sold through a co-op.

Mr D recognises that the critical dimension of quality is skin finish, followed by the size and shape of the tubers. The land is highly susceptible to common scab, and the potato varieties offer low resistance to this disease, so in consequence Mr D has developed an intensive regime of irrigation which relies on four irrigators and high levels of labour input. In fact, Mr D acknowledges that the capacity of the irrigators cover an area in excess of the actual potato acreage, but this is a deliberate strategy in order to ensure he can apply water immediately the crop needs it. Mr D follows a strict programme of irrigation on the pre-pack varieties whereby half an inch of water is applied every three to four days, as opposed to the standard application of an inch of water every seven days, in order to reduce wastage through run-off and evapo-transpiration. The crop is closely monitored, with Mr D walking the crop every day and irrigation starts immediately on tuber initiation for a six week period to prevent the onset of common scab. Mr D is unwilling to compromise on potato quality and thus the increased labour and capital costs attached to this irrigation regime are perceived as essential in guaranteeing the high quality and the associated premium prices.

The introduction of the processing chip varieties in 1992 was a direct consequence of the drought experience and the threat of abstraction restriction in the 1991 season. Although Mr D ceased irrigation of all low value cereal and sugar beet crops he was still unable to guarantee sufficient water to irrigate his entire potato area. In consequence Mr D switched 50% of the potato acreage to the processing varieties, and relieved the pressure on his water resources. These varieties do not require irrigation to control the incidence of common scab and so Mr D is able to guarantee irrigation to the pre-pack varieties in this early period and ensure that they conform to the skin finish specifications.

The development of this complex marketing approach enables Mr D to reduce the level of financial risk and uncertainty associated with potato production, as the forward contract ensures a return on his investment. An alternative strategy, would involve investment in water storage providing a reliable supply of water and enabling continued growth of the pre-pack potatoes. However, this option was rejected because of the increased risk exposure and higher capital gearing.

Uncertainty over their ability to consistently meet the pre-pack quality specifications has been a key factor shaping the development of this marketing approach. Limited water resources, as well as unreliability of abstraction supply, prevent these farmers from instigating an intensive irrigation regime on their entire potato area. Thus, without changes these farmers were liable to incur significant financial losses by producing poor quality potatoes. The introduction of processing varieties under forward contract agreements offers a number of advantages, as the quality specifications, although rigorous, do not require a strict irrigation programme to control the appearance and skin finish of the potatoes. A dual marketing approach ensures sufficient water is available in the early part of the season for the pre-pack varieties and thereby safeguards the production of quality potatoes, and the associated premium prices. This approach also succeeds in

reducing the financial risks and uncertainties associated with potato production by insulating the farm from the extreme low prices which often afflict the open market. These farmers have adopted a risk averse strategy in which they trade off the financial and production risks and uncertainties associated with engagement with different quality networks, against their vulnerability to the hazards of low rainfall and abstraction restrictions.

(iii) Incorporation into the processing potato network: Forward contract production only.

The final marketing approach identified in the sample involves forward contract agreements for all potatoes and root vegetables. A total of six farms are involved in the crisp potato network, with two farms combining this with the production of vegetables under forward contract agreements. The development of this marketing approach reflects the farmers' assessment of the relative financial risks and uncertainties associated with potato and root vegetable production. The extreme fluctuations in potato and root vegetable prices critically influence their perception and assessment of the range of alternative marketing options, in particular sale on the open market. Despite this, the farmers have not opted out of production as they are critically influenced by policy changes emanating from the EU over the reform of the CAP.

At the time of interviews, the future of the CAP was uncertain, with policy reforms potentially cutting cereal prices dramatically. In consequence, these farmers felt it was important to maintain their interests in potato and vegetable production, as these crops fall outside of the CAP regime, and thus insulate them from the impact of major cereal price cuts. By tying production of high value and high risk crops to forward contract agreements, the farmers succeed in avoiding the financial risks associated with fluctuating produce prices, while at the same time insulating the farm from the impact of CAP reforms. The area under potato production averages 68 hectares; however, there are marked differences, with a total of three farms growing less than 25 hectares, compared to the other farms where potatoes take up between 100-200 hectares. The financial and production risks incurred by these farmers are distinctly different given the scale and intensity of production.

Three farms which all grow less than 25 hectares of potatoes have a long involvement in processing potato production stretching over a 15 year period and have never ventured into marketing through the open market. These farmers recognise the advantages of this approach, namely a guaranteed financial return on their investment, with a clear agreement on the price established at the beginning of the season. The farmers are critically aware of the importance of consistently conforming to the quality specifications, with the ever present threat of crop rejection or reductions in price. In consequence, they closely co-ordinate production in line with the advice provided by the processing firm in the pre-season contract negotiations and the advice booklets.

These farmers argue that irrigation is a vital element of production and is reserved solely for the potato crop, with the total licensed quantity of water averaging 23 megalitres. Investment in irrigation is low, with the farmers all utilising second-hand machinery, and consequently the annualised cost of investment only ranges between £1915 and £719. The replacement or repair of irrigation equipment could significantly increase the costs of irrigation and render continued potato production uneconomic over the long term. This is revealed in the long term gross margin analysis, where under the £50 potato price scenario two of the farmers incur negative values, and under the £80 scenario all three farms incur losses of less than £7,000 when irrigation water is withdrawn. Replacing irrigation equipment would significantly increase their costs, as would an increase in the unit cost of abstraction water and these factors could hasten the shift out of irrigation.

The three other farms are far more complex, as they grow between 100-200 hectares of processing crisp potatoes as well as between 60-190 hectares of vegetables which are all irrigated. With such large areas of high value crops under production, it is vital that these farmers consistently meet the quality specifications, as minor quality defects can translate into significant reductions in the total value of the crop. Irrigation is therefore central to the success of this marketing approach, enabling the farmers to consistently meet the quality specifications and thereby fulfil their contract

agreements. The financial importance of this is revealed in the long term gross margin analysis where the losses incurred by switching to the dry farming option under the £80 scenario range from £177,372 to £371,270. In fact, these farmers have undertaken significant investment programmes in irrigation, with the annualised cost of investment ranging from a low of £49,000 to a high of £136,231. Such major capital investment in irrigation represents an important financial risk management strategy, which enables the farmers to not only ensure the consistent quality of produce but also allows them to introduce other vegetable crops into the rotation. This succeeds in reducing the area under cereals and the potential impact of CAP price reform, as case study 5 reveals.

Farm case study five is farmer E who operates a highly sophisticated and capital intensive system of irrigation which includes centre pivot systems, on his 403 hectare sandland farm. A total of 454.5 megalitres of water are licensed for irrigation from ground water sources, which enables Mr E to grow a combination of high value crops including 100 hectares of potatoes; 20.2 hectares of carrots; 20.2 hectares of parsnips and 40 hectares of onions which all receive water at various stages through the season. In the past sugar beet and cereal crops also received irrigation, but this has now stopped as a direct result of the drought of 1989-92. The vegetable crops are either grown under formal forward contract agreements or informal share crop arrangements, in a deliberate attempt to reduce the level of financial risk and uncertainty associated with the production and marketing of high value crops.

Forward contract agreements for the production of processing crisp varieties cover the entire area of potatoes, and Mr E is directly involved in negotiations with the processing firm. Mr E acknowledges water is vital to the production of this crop, as the contract is for production of the Saturna variety which is highly intolerant to drought. Irrigation is critical, to ensure not only the growth of the crop but also to guarantee the quality. Mr E closely co-ordinates the production of this crop in line with the advice provided by the processing firm, and uses a specialist off-farm irrigation adviser to guide irrigation application. Mr E argues it is critical for the crop to consistently conform to the quality specifications, as the processing firm will reject the crop and the variety is virtually impossible to sell on the open market. Mr E would therefore incur significant financial losses as the price would fall from £80/t under the contract agreement to £30/t if the crop is sold as stock feed.

The parsnip, carrot and onion crops are all produced under various share crop or partnership agreements with specialist growers and pre-packers. Under these agreements, Mr E shares the production costs and all decision making in relation to the crop with other off-farm firms, who provide specialist planting and harvesting equipment and are entitled to a percentage of the profits. Once again water is a vital element in the production of these crops, to ensure they conform to the quality and size specifications demanded by the supermarkets.

The farmer's perception of financial risk and uncertainty critically shapes the development of this marketing strategy. Ensuring a return on investment is a critical factor shaping his interaction with the down-stream network as Mr E is critically aware of the impact CAP reforms will have on his cereal crops. The extension of the set aside programmes will further reduce the level of profits on these cereal crops. Consequently, reducing the level of

dependence on these subsidised crops, by increasing the area of high value potato and root vegetable crops under production, enables Mr E to insulate the farm from future changes in the CAP regime.

The marketing of high value crops through forward contract agreements succeeds in reducing the level of financial risk and uncertainty associated with production, insulating the farm from the extreme low prices which can afflict the open market. Despite this, there are still significant financial and production risks associated with forward contract agreements, as the produce must consistently conform to the quality standards set out in the agreement. Failure to consistently meet the standards allows the processing firm to reject the crop or significantly reduce the price, and in these circumstances, the farmer can incur significant financial losses. Access to, and use of, reliable supplies of irrigation water are therefore central to the success of the farmers' interaction with the off-farm firm, ensuring not only the growth of the drought susceptible varieties, but also preventing the onset of quality problems.

The overriding importance of produce quality is underlined in the analysis of these three marketing approaches, as farmers are closely integrated into the quality "projects" of the down-stream food network. The analysis demonstrates the extent to which the off-farm firms succeed in indirectly regulating on-farm production decision making, controlling both production and labour time on the farm, while avoiding the risks associated with land ownership and agricultural production.

Nevertheless, farmers are not passive bystanders in this process and the analysis demonstrates how the close integration of the quality projects into their own management practices enables them to reduce the risks and uncertainties associated with production and in turn achieve the high and premium prices.

Access to, and use of, reliable supplies of irrigation water are central to the success of these three marketing approaches, as the production of quality potatoes is inextricably inter-twined with irrigation use. Failure to consistently conform to the quality specifications, through poor irrigation

management or unreliability of abstraction supply, can result in significant financial losses. In fact, at the most extreme, unreliability of irrigation water has directly resulted in a total of six farms, moving out of potato production in the aftermath of the drought of 1989-92. Access to, and use of, reliable supplies of irrigation water played a central role in this decision, as they were unwilling to incur the financial losses associated with poor quality produce. These farms, all located in the Bain-Witham catchment study area, hold a combination of surface and ground water abstraction licences for an average of 38.8 megalitres ranging from 9 to 69.55 megalitres². Nevertheless, these licences were insufficient to operate an intensive regime of irrigation on the entire potato area, and these problems were further compounded by unreliability of abstraction supply. Consequently, through the drought years of 1989-92, these farmers produced poor quality potatoes afflicted with common scab and poor yields, which failed to meet either the pre-pack or processing potato standards and were sold off as stock feed. The financial losses were high and the farmers were unwilling to invest in water storage or new irrigation equipment to alleviate the problems. Instead they cut their losses by moving out of potato production and irrigation altogether, thereby avoiding further capital investment and future uncertainty. The shift in emphasis by the fresh potato network to strict potato quality standards, in particular those related to skin finish, marginalises those farmers who hold insufficient irrigation licences to instigate the necessary irrigation programme.

Access to, and use of, reliable supplies of irrigation water are central to the success of quality potato production, and has resulted in the intensification of water use on the farm. The quality specifications, particularly in relation to skin finish, fuel the demand for irrigation water and leave farmers vulnerable to drought, low rainfall and abstraction restrictions. Farmers have responded to these pressures by introducing a number of changes into the management and use of irrigation water. The analysis reveals how farmers have critically re-evaluated the value in use of irrigation on their different crops, resulting in the reallocation of water from low value cereal or sugar beet crops

² Although these farmers have all stopped irrigation, they still retain their licences, recognising the value added to their land.

to high value potato and vegetable crops. These changes were introduced in response to the physical scarcity problems encountered through the drought of 1989-92. Some farmers have realigned their potato marketing approach, introducing processing varieties in order to ensure sufficient water for an intensive irrigation programme on their pre-pack varieties. Other farmers have invested in water storage facilities, securing a reliable supply of water, thereby ensuring themselves against future abstraction restrictions. These changes have been introduced with the primary objective of avoiding the financial risks and uncertainties associated with producing poor quality produce. As a side effect, they have also succeeded in reducing the stress which irrigation places on the environment. Nevertheless, these are unintended benefits and the result of farmers pursuing their own narrowly defined economic self-interests. Farmers have avoided introducing management changes which compromise their ability to produce quality potatoes, and they have left unchallenged the key factors fuelling their demand for water, namely the variety and quality specifications of the down-stream food network.

Farmers are responding to the financial and production risks and uncertainties which are imposed on them through their interaction with the down-stream food network. In order to ensure the consistent quality of produce and thereby the premium prices, they are reallocating their own resources of land, labour, capital and water, resulting in a highly water and capital intensive system of production. As farmers are not forced to internalise the full costs, in both economic and environmental terms, of their irrigation decision making they succeed in reallocating the environmental risks and uncertainties associated with irrigation use for others to bear. Consequently, the continual rise in demand for irrigation water, imposes economic and environmental costs which are borne by the other users and uses of water and is reflected in the greater stress on water resources and the water environment in the summer months.

6.1.3: Farmer knowledge and perception of water, water rights and the water environment.

The analysis thus far has demonstrated how farmers' use and management of irrigation water is critically shaped by their perception and assessment of financial risk and uncertainty. Ensuring production consistently conforms to the quality standards of the down-stream food network overrides all other considerations. Environmental risk and uncertainty rarely impinge on farmers' irrigation decision making as they are divorced from the impact on down stream river flow levels. Consequently, policies which have no direct benefits to individual farmers, but are designed to ensure the protection of specific water environments, may encounter problems as farmers fail to respond in the prescribed manner. This failure may partially be explained by the predominance of economic self interests or reflect ignorance or lack of information on the environment. As the theory of the firm and behaviouralist literature on risk and uncertainty highlight, unequal access to information within the firm, lack of information on the range of alternative management options, and information gaps shaping the perception and assessment of risk, prove critical in distorting the response of individuals and farms to specific environmental policies (Dasgupta 1982; Segersen 1992). In fact, a pre-condition for a rational response to water demand management policies is the abstractors' awareness of existing water prices, knowledge of their water consumption levels and understanding of the range of alternative water saving options and associated costs (Rees *et al* 1993). Consequently, exploring farmer knowledge and perception of water, water rights and the water environment is critical in understanding the trade-offs calculated between the relative financial, production and environmental risks and uncertainties associated with a specific policy proposal or course of action.

Exploring farmer knowledge and perception of water, water rights and the water environment is not amenable to simple unequivocal answers, as the farmers themselves give somewhat confusing and contradictory responses. Farmers are critically aware of the importance of maintaining access to, and use of, reliable supplies of irrigation water. 74% (48) of the sample claim irrigation is vital to the success of their farm management strategy, and in fact 100% of potato, root vegetable and

resource sub-contractors claim that without irrigation they would stop production of these crops. This perception belies the critical financial benefits associated with irrigation use, and underlines how protection of their economic self interests will play a central role shaping their response to alternative water policies. In line with this, 89% (58)³ of the sample knew the full details of their abstraction licence and were able to quote the licensed quantity of water, period and location of abstraction. These farmers were also fully aware they were on Section 63 Agreement, where they pay for 50% of the water licence at the beginning of the season. Consequently, reforms of the abstraction licensing system or charging scheme will not be hindered by farmers' lack of knowledge on the details of their abstraction licence, or unawareness of the current water abstraction charging scheme. This by no means guarantees a positive response to policy reforms. The analysis reveals there are a number of misconceptions surrounding not only the division of regulatory responsibilities between the NRA and Water Companies, but also the response to a number of demand management policy options is somewhat confused by the negative attitudes towards the Water Companies. Overcoming these barriers will prove critical in ensuring a positive response to policies designed to protect the water environment.

Moving beyond these misconceptions and prejudices is vital in order to gain a deeper understanding of farmer knowledge and perception of water and the water environment. However, this proved a difficult subject area to explore through the focused interviews. Questioning focused on comparison of irrigation with other farm management practices and made use of hypothetical scenarios, in order to indirectly reveal farmers' (mis)understanding of water issues. A number of critical issues are highlighted. The management and use of irrigation water is perceived as an uncertain arena of decision making. Compared to the use and management of other farm inputs,

³ These figures compare favourably to results recorded by Rees *et al* (1993), where 79% of the sample knew the full details of their abstraction licence. The higher positive response rate in this study reflects the nature of the water conflict in the three study areas, where access to and use of water is an increasingly politicised arena of conflict in the aftermath of the 1989-92 drought.

namely fertilisers, pesticides and herbicides, 79% (51) of the sample argued that access to, and use of, irrigation water was subject to greater uncertainty, and this is illustrated by Mr R who argues

“Well fertiliser, pesticide and seed are always readily available in the quantity that you want, whereas water is more difficult to buy and more difficult to apply and more difficult to guarantee. It is not the free source which everybody thinks that it is, and you can’t get another million gallons of water when they have switched you off” (Mr R).

Farmers recognise they do not retain full control over irrigation water decision making, as there is uncertainty over both the availability and reliability of abstraction water when compared to the management and use of fertilisers and pesticides. This is understandable as there are, at present, few restrictions on the usage of these inputs, where farmers are able to purchase external advice and inputs from a wide number of merchants across the county. The level of uncertainty in this arena of production decision making is therefore almost non-existent over the short term, as farmers are able to purchase the inputs with no restrictions⁴. These uncertainties have a direct impact on the development of on-farm water management strategies. 79% (51) of the farmers claimed they are unable to plan or predict their use of water at the beginning of the season, they are unable to state “we will start irrigating by the first of May and stop by the second week of August”; the level of rainfall variability makes this impossible. However, these farmers do expect to use their irrigation at some stage in the season on the basis of their past experience of weather conditions in the locality. Farmers’ past experience of unreliability of supply will play a central role shaping their willingness to incorporate new or alternative irrigation practices into their water management plans at the farm level. In fact, the pace of change may be relatively slow, as farmers’ response to demand management policies will be critically influenced by the incidence of ‘extreme’ low rainfall events. Only when they have actually experienced these conditions will they instigate change to water management strategies designed to cope with ‘normal’ low rainfall conditions.

⁴ Nevertheless, there is uncertainty over the long term use of these inputs with the possible introduction of nitrogen restrictions and the extension of the Nitrate Sensitive Area designations. However, none of the farmers in the sample are responding to these uncertainties by reducing their use of nitrogen or changing their management practices.

Farmers' perception and conceptualisation of water abstraction licences provides critical insight into their understanding of water rights, as well as their attitudes to water regulation and controls. In fact, two distinctive groups emerge in the sample with one set of farmers arguing land rights automatically establish water rights, while a second group argue access to water is not a right but a licence with precise constraints determining usage. Surprisingly, only two farmers claimed access to water was a natural right which should not be regulated, allowing the unconstrained use of water. Despite these two cases, the remainder of the sample argued in favour of regulation and policing of water use and recognised the importance and higher moral right for all humans to have access to water for domestic supplies. In fact, farmers are critically aware of the vital role of regulating water usage to ensure humans are guaranteed water to meet their basic needs. However, this does not imply that farmers perceive all urban demands for water as equally valid. In particular, farmers resent the inequitable system of abstraction restrictions whereby irrigation is banned, while domestic users are still allowed to water gardens and lawns. This system fuels the perception that the regulatory system places green lawns and lush domestic gardens above the needs of farmers to grow crops. Although farmers recognise they are competing with domestic users for new supplies of water they seem unaware that they are also directly competing with the environment. In fact, farmers' perception and knowledge of the impact of their irrigation abstraction on the water environment is very limited. Only one farmer recognised his abstraction had any impact on river flow levels and the *in situ* water environment. Of the remaining farmers, 37 claimed there was no impact at all, 12 farmers gave confusing and contradictory answers and 12 refused to answer. Unsurprisingly, of those who claimed that abstraction had no impact on the water environment 13 claimed that Water Company abstraction did more harm to the water environment than irrigation, as Mr X argues

"I think the impact of our use is minimal. We have four Anglian Water bore holes within three quarters of a mile of this farm and they are pumping out over a million gallons each. I think those requirements should be examined more closely to assess the environmental damage" (Mr X).

Recognition that Water Company abstraction poses greater threat to the environment - although in reality true - ignores the fact that irrigation also directly affects the environment. As documented in Chapter Four, abstraction for irrigation imposes greater stress on the water environment in the summer months, as the rate of abstraction during the peak period is greater than Water Company demand. The failure of farmers to recognise the environmental consequences of their abstraction may reflect their limited knowledge and understanding of the complex intricacies of the water cycle. The full extent of this gap in farmers' knowledge is unknown, although it is partially reflected in the number of farmers who gave confusing or contradictory responses. The farmers also attempt to distance themselves from the impact of abstraction on the environment, by shifting responsibility for change to the water companies, thereby succeeding in avoiding any changes to their own irrigation management practices.

This analysis demonstrates the confusing and contradictory nature of farmers' knowledge and perception of water, water rights and the water environment and consequently these results must be interpreted with extreme caution. On one level access to information, reflected in farmers' knowledge of licence details and water costs is not a problem and will not undermine their response to demand management policies. Despite this, the analysis also reveals the deep-seated lack of awareness among farmers of the environmental issues tied up with irrigation use. Only one farmer recognised the potential impact of his abstraction on the water environment, and this critical gap in farmers' knowledge may potentially distort their response to policies designed to protect the water environment. This lack of information will in turn feed into, and shape, the conflict over access to and use of reliable supplies of water. In light of this, it is therefore not unsurprising that environmental risk and uncertainty is largely ignored in farmers' irrigation decision making as lack of information feeds into, and shapes, farmers' poor perception of water as an environmental issue (Dasgupta 1982; Segersen 1992).

6.1.4: Irrigating for quality: the implications for demand management policy.

The policy implications which can be drawn from this analysis are far reaching, exposing not only the key factors influencing irrigation management at the farm level, but also providing critical insight into the processes likely to shape farmers' response to demand management policies.

Economic incentives are a central plank of water demand management policies, involving both incentive pricing of abstraction water and tradable permit systems (see sections 4.2 and 4.3 for discussion of these issues). In theory, these policy measures should lead to a reallocation of water from low to high value uses, and a movement towards water conservation. In fact the analysis reveals how farmers are already responding to the problems of physical water scarcity and the price differential between summer and winter abstraction, by constructing water storage facilities and reallocating water from low to high value crops. These processes of change could in theory be further reinforced through the introduction of demand management policies. Nevertheless, this analysis will pinpoint a number of critical factors which could potentially distort the response of farmers and lead to unintended consequences and side effects, undermining the sustainability of inter-dependent economic and environmental systems.

(a) Incentive pricing of abstraction water.

The introduction of incentive pricing of abstraction water will significantly reform the economic signal relayed to farmers. Although current abstraction charges for irrigation water do differentiate between summer and winter abstraction, in reality the size of these differentials is relatively small, with the Anglian region only charging £22.54/megalitre for summer irrigation water compared to £2.25/megalitre for winter abstraction. These prices are too low and consequently water costs rarely impinge on the decision making of farmers through the season (Rees *et al* 1993). This is revealed most starkly on those farms which hold both summer and winter abstraction licences. These farms operate irrigation systems whereby summer abstraction licences are used first, in order to pre-empt the imposition of abstraction restrictions, and thereafter switch to use winter reservoir water. This is an important risk management strategy, as winter water is reserved to ensure sufficient water for the

potato crop in the later stages of the season, and thereby guarantee the produce quality. Thus, the current price differential is too low to challenge farmers' existing management and use of irrigation water, leaving unchanged their perception and assessment of the relative environmental and financial risks and uncertainties tied up in irrigation use.

Despite the limitations of the current abstraction charging scheme, the short and long term gross margin analysis reveals how irrigation is already only marginally viable on some farms. In the short term gross margin analysis, a total of 18 farms incur negative values under the £50 potato price scenario, and would be better off switching to the dry farming option. Of these, 10 are small farms holding irrigation licences for less than 30 megalitres of water and producing less than 25 hectares of early or processing potatoes. When the annualised cost of irrigation investment is included in the long term analysis, these farms are deemed uneconomic under both the £50 and £80 potato price scenarios. Thus, if these farmers are profit maximisers they should already be critically re-evaluating their irrigation use and shifting to the dry farming option.

The gross margin analysis demonstrates the wide variation in the values in use of irrigation water, and although irrigation on some farms is not viable, on others the potential losses incurred from moving out of irrigation to dry farming are significant. The short-term gross margin analysis reveals a total of 19 farms will potentially incur losses in excess of £100,000 under the £150 potato price scenario by moving out of irrigation (see table 6.1). In fact the average loss per authorised megalitre under the £150/t potato price scenario equals £2007.67 per megalitre which is greatly in excess of the current authorised abstraction charges. Even when the real opportunity cost of capital invested in irrigation equipment and storage facilities is included in the long term gross margin analysis, the potential losses incurred by moving out of irrigation are still high, with the average loss under the £150 potato price scenario amounting to £1432. It should be noted however, that these average figures mask the wide variation in values, with some farmers incurring losses in excess of £5000 per authorised megalitre. In addition, the analysis reveals that for a total of 8 farms,

production is deemed uneconomic under both the £50 and £80 potato price scenarios when their annualised investment costs, in excess of £50,000, are included. Consequently, these farmers are locked into a highly water and capital intensive system of production, in which they must achieve the high potato prices of £150/t in order to ensure a return on their investment.

The close incorporation of these farmers into the quality projects of the down-stream food network will critically distort their response to an increase in the unit cost of abstraction water. Financial risk assessment plays a central role in irrigation decision making for those farmers operating water and capital intensive systems of production, it is possible that price rises will simply be absorbed and not trigger the shift in behaviour postulated by neo-classical environmental economics. The critical question for policy makers therefore, focuses on the magnitude of the price rises necessary to shift farmer behaviour to encourage the wise use of water.

The increase in prices necessary to ensure water conforms to the principles of long term marginal cost (LMC) pricing is by no means insignificant. Evidence from Dubourg (1995), Bate and Dubourg (1995) and Rees (1997) suggests water abstraction charges will have to rise 10, 20 and 100 fold in order to reflect the full costs of water supply. This translates into a dramatic increase in the unit cost of irrigation abstraction, which in the Anglian Region would rise from the current charge of £22.54 for summer abstraction to £225, £450 and £2,254 respectively. Incorporating these figures into the long term gross margin calculations enables the analysis to trace the impact on the long term viability of irrigated production. Using the range of alternative prices, the analysis should pinpoint the water price levels which potentially undermine the viability of irrigation on some farms, and thereby trigger changes to the use and management of irrigation water. This is demonstrated in table 6.3, where the new water prices levels of £225, £450, £696 and £2254 are added to the annualised equipment costs. These figures exclude the cost of investment in water storage facilities, and the water costs are calculated on the basis of summer licensed abstraction only. The new cost figure is then subtracted from the gross margin achieved by irrigation under the

three potato price scenarios, and the results compared with the gross margins achieved under the dry farming winter wheat option.

The response to the alternative water price rises is likely to vary dramatically, reflecting farmers' differential incorporation into the quality projects of the down-stream food network and the associated potato price premiums. This is demonstrated in the analysis where the aggregate figures reveal the non-viability of irrigation under the £50 potato price scenario for all four water price levels. The losses incurred under the £150 potato price scenario underline the continued viability of irrigation under three water price levels, although as expected the size of the losses declines markedly. These aggregate figures however, mask important differences at the farm level, and disaggregating the sample farms in line with the three marketing approaches developed in section 6.1.2, reveals a number of critical factors.

Firstly, for those farmers marketing potatoes solely through the fresh potato network the water price rises have a markedly different impact, as the farmers gear production to the high quality and high prices associated with pre-pack and early potatoes. At the £225 price level, only two farms incur negative values under all three potato price scenarios and these are small farms, producing early potatoes, and heavily reliant on unpaid family labour and old or second-hand machinery. Nevertheless, the fact that only two farms are rendered uneconomic is somewhat surprising as the analysis in section 6.1.2 projected that 9 small family farms would be vulnerable to increases in the variable and fixed costs of production. In fact, if these farms are forced to accept the lower potato price of £80/t then five of the nine farms incur negative values and would be better off switching out of irrigation. The annualised cost of irrigation investment on these farms is low, as the farmers take advantage of second-hand machinery or equipment purchased in the 1960's, and consequently the decision to replace this machinery may prove sensitive to LMC pricing. An increase in the annualised cost of investment combined with the £225/megalitres water price would render irrigation uneconomic.

£225 Water cost scenario	£50	£80	£150
Irrigated gross margin	12,633,625	13,751,734	15,724,988
Annualised irrigation capital cost plus £225 water cost	1,988,133	1,988,133	1,988,133
Difference	10,645,492	11,763,601	13,736,855
Wheat gross margin	11,058,728	11,058,728	11,058,728
Difference n=35	-413,236	704,873	2,678,127
£450 water cost scenario			
Irrigated gross margin	12,633,625	13,751,734	15,724,988
Annualised irrigation capital cost plus £450 water cost	3,028,333	3,028,333	3,028,333
Difference	9,605,292	10,723,401	12,696,555
Wheat gross margin	11,058,728	11,058,728	11,058,728
Difference n=35	-1,453,436	-335,327	1,637,927
£696* Water cost scenario			
Irrigated gross margin	12,633,625	13,751,734	15,724,988
Annualised irrigation capital cost plus £696 water cost	4,161,603	4,161,603	4,161,603
Difference	8,472,022	9,590,131	11,563,385
Wheat gross margin	11,058,728	11,058,728	11,058,728
Difference n=35	-2,586,706	-1,468,597	504,657
NB. £2250 price level all negative values			

Table 6.3: The long run gross margin response, incorporating the alternative LMC price of abstraction water.

*Reflects the cost of mains water in the Anglian region, a 30 fold increase in the cost of abstraction water.

The response of the water and capital intensive producers of pre-pack baking potatoes is markedly different, as under the £225 water price level none incur negative values and the losses on the five farms range from £31,687 to £407,095. Only when the price level rises to the £450 level is production rendered uneconomic and then only one farm is affected. Of the remaining four farms, three incur losses of less than £50,000 while one farm incurs a loss of £306,062. These trends are broadly replicated at the £696 water price level, with two farms incurring negative values.

Consequently, with such a wide variation in the values in use, the response of these farms to LMC

pricing will potentially vary widely, with farms incurring losses in excess of £300,000 simply absorbing the water price rises even at the £696 level. Remaining farms may prove sensitive to water price increases; in particular the shift in price from £225 to £450/megalitre should lead to changes, as irrigation is either deemed uneconomic or the economic benefits of continued irrigation although still viable, decline markedly.

Under the dual marketing approach a total of six out of the nine farms incur negative values when combining the £225 water price level with the £80/t potato price scenario. This response is partly explained by the fact that these farmers have invested heavily in irrigation equipment to ensure the quality of their pre-pack baking potatoes. Consequently, the combination of high annualised capital costs and higher water prices renders irrigation uneconomic if forced to accept the £80/t potato price on their entire potato area. In reality, the response of these farmers will prove more complex as they combine processing and pre-pack quality baking potatoes, and under the £150 potato price scenario none of these farmers incur negative values at the £225 or £450 water price level. Only when prices rise to the £696 level is production rendered uneconomic, and then only two farms are affected. The annualised cost of irrigation plays a central role on the final three farms undertaking this dual marketing approach, where investment in irrigation is low. Consequently, the increase in water prices, even to the £696 levels does not render irrigation uneconomic at the £80 or £150 potato price scenario. Nevertheless, the replacement or repair of irrigation equipment could again prove sensitive to LMC pricing as higher water and annualised investment costs render irrigated production uneconomic.

Finally, for those six farmers producing potatoes solely under forward contract agreements, the response to increased water prices varies markedly, reflecting differences in the total area under potato production. At the £225 water price level only one farm incurs negative values at the £80 potato price scenario. The level of losses incurred by the other five farms are significantly different, with two farms incurring losses of under £1500 while three farms achieve losses in excess of

£500,000. In fact, those farms incurring negative values and losses below £1500 are all small family farms, producing potatoes on less than 25 hectares and largely utilising unpaid family labour and second-hand equipment. Continued irrigation on these farms is not viable at the £225 price level. In contrast, the three other farms are large estates producing 100-200 hectares of processing crisp potatoes and other vegetable crops. The rise in water prices, although reducing the size of their losses, does not in any way render irrigation on these farms uneconomic even at the £696 water price level.

Incorporating the alternative long run marginal costs of water supply into the analysis demonstrates the potentially different impact which LMC pricing will have on farmers. The £225 price rise should prove sufficient to shift the behaviour of small family farmers irrigating relatively small areas of potatoes. Irrigation on these farms is of marginal viability and they would be better off switching out of irrigation to the dry farming option. Although this process of change may not be immediate, these farmers would critically reassess their irrigation use, when faced with a decision on the replacement or repair of irrigation equipment. Higher annualised costs of investment, combined with a water price of £225/ megalitre, should trigger movement out of irrigation.

In contrast, the impact of price rises on large, water and capital intensive potato producers is more complex. The analysis demonstrates how these farmers will still incur significant financial losses from moving out of irrigation, when the alternative water costs are included. Thus, the water price rise to the £225 level may simply be absorbed, as long as the farmers are still able to consistently produce the high quality potatoes with the consequent premium prices. Nevertheless, this situation changes significantly if the farmers are unable to achieve the high premium prices. Under the £80 potato price scenario, production on some of these farms is deemed uneconomic when including the £225 water price level, particularly those with high levels of investment in irrigation. Thus, farmers' perception and assessment of the relative risks and uncertainties associated with production and marketing of the crop, will prove critical in shaping their response to water price rises. In fact,

the option of constructing on-farm water storage facilities may prove more attractive, as the benefits in terms of a reliable supply of water, reduced risk of producing potatoes which do not conform to the quality specification, as well as the not inconsiderable cut in water costs, may outweigh the costs of reservoir construction, even on the flat sand land of Norfolk and Suffolk. Needless to say, these assessments will be critically influenced by the farmers' incorporation into the "quality" projects of the down-stream food network, and will play a pivotal role shaping farmers' response to incentive pricing schemes.

(b) Tradable permit systems.

The introduction of tradable permit systems should in theory lead to a reallocation of water from low to high value uses. Currently under- or un-utilised licences could be traded, to meet the demand for water from other users and uses, and put off to some future date investment in new water sources. The design and implementation of a tradable permit system in the agricultural sector could release the significant quantities of un-used water tied up in licences of right, which contribute to the marked differential between licensed and actual abstraction. In theory, the design and implementation of a tradable permit system should conform to the principles of economic efficiency, in reality however, significant social and environmental factors will have to be addressed, which could distort the efficient operation of the system. Central to this dilemma is uncertainty over the response of farmers to a tradable permit system, and the unintended consequences and side effects which may result. Potential problem areas are revealed through detailed scrutiny of the unofficial water market which has developed in the Lark and Thet-Little Ouse study areas. Analysis of farmers' response to the revaluation of water resources should provide critical insights into the key factors which will potentially shape farmer behaviour in a tradable permit system and the unintended environmental consequences and side effects which result.

Resource sub-contracting represents a markedly different approach compared to the others identified so far in this analysis. Farmers' inter-relationship and negotiations with the down-stream food network revolve around the question of land and water rights, rather than the marketing of actual produce. In fact, these farmers have no involvement in the actual production of potatoes and root vegetables, and instead sub-contract their land and water rights to a third party, who grows the high value crops. In total 10 farms, all located in the Lark and Thet-Little Ouse catchments, sub-contract land and all, or part, of their water licence, to third parties, who are specialist growers and pre-packers of root vegetables operating in the Breckland area (see section 5.2.3, Chapter Five for discussion of these firms). These firms pay a fixed acreage payment for the rental of the sand land with the water rights attached, which amounts to £200-300 per acre for the land and an additional payment of £20-25 per acre inch for the actual quantity of water used.

Access to irrigation water is vital to these firms, and they will only rent land if there is sufficient water to irrigate the crop. The actual owner of the land and licence holder has no involvement in the production of the crop, and the commercial grower retains direct control over all production decision making. This represents a complex form of tradable permit system, as access to irrigation water is re-valued and commodified by off-farm interests who create an unofficial market for water plus land rights. Obviously, the constraints imposed by the licensing system, in which irrigation water rights are confined to certain areas of land, are by-passed as the farmer rents out both the water and land rights, and receives payment for water greatly in excess of the unit water charges imposed by the official abstraction charging scheme. In addition, the rental value of the land is also higher because of the attached water rights and therefore the farmer gets a double benefit. These farmers sub-contract an average area of 49 hectares, which is used primarily to produce carrots, parsnips and onions, which represents between 6% and 47% of their total utilised area. Critically, the water resources licensed to these farms average 210.89 megalitres ranging between 63 and 465 megalitres, and between 25-100% of this water is available for use by the off-farm firm. Without the option of resource sub-contracting, this water would be largely un- or under- utilised and

demonstrates the potential surplus water available for reallocation through an official tradable permit system.

Sub-contracting land and water rights to an off-farm firm offers a number of advantages to the farmer and reflects their perception of financial and production risk and uncertainty. Firstly, and most importantly, the income which the farmer receives under this agreement represents a risk free source of finance, as the farmer is not liable for any of the capital or variable costs associated with production. They are guaranteed a fixed return from the land at the beginning of the season and face none of the financial risks and uncertainties associated with the production or marketing of the crop. Secondly, by introducing sub-contracting into their rotation, the farmers succeed in reducing the area under cereal production and the CAP regime. This is an important influence shaping the development of farm management strategies, as the farmers respond to the uncertainty over the future of the CAP and the potential cuts in cereal prices and subsidies. By switching land into sub-contracting the farmers reduce the area of subsidised crops and thereby reduce the impact of reform. Finally, the introduction of sub-contracting, particularly where it represents in excess of 30% of the total utilised area, enables farmers to restructure their labour and capital resources to reduce costs. This has been a critical influence on four farms, where the introduction of sub-contracting has been accompanied by redundancies and the sale of heavy farm equipment and machinery, enabling the farmers to realise some of their assets. These financial risks and uncertainties play a central role shaping farmers' involvement in the sub-contracting relationships. The re-valuation of water rights by off-farm firms, and the emergence of a market for land with water rights forced these farmers to re-evaluate their own use and management of irrigation water.

Of the ten farms undertaking resource sub-contracting, seven farmers had already invested in irrigation, and the water was largely under- or un- utilised as it was used solely for the sugar beet crop. Although the annualised cost of this investment averages £15,148, the real cost to the farmers was significantly lower, as they all obtained Government grants under the old FHDS schemes.

Consequently, the tax payer subsidised investment which was only ever used in a drought year to ensure sugar beet production fulfilled the quota tonnage. This represents a risk reduction strategy, which guarantees a fixed income from the sugar beet crop even in a dry year. The emergence of the unofficial market in water encouraged these farmers to reallocate their water away from the sugar beet crop, as the financial return from sub-contracting is higher than the marginal improvement in yield achieved by irrigating the sugar beet crop. With capital already committed to irrigation, and in part subsidised by the taxpayer, these farmers are taking advantage of new market opportunities.

This stands in marked contrast to the final three farms which have actually invested in obtaining an abstraction licence and irrigation equipment with the sole intention of sub-contracting land and water rights to off-farm firms. These farmers recognised the financial opportunities attached to the emerging market in water and land rights and decided to obtain water abstraction licences in the late 1980's to enable them to switch between 30-47% of their total utilised area into sub-contracting. These family owned farms of between 100-200 hectares all utilise summer and groundwater abstraction licences. The farmers recognise the value of water and have capitalised on their position as land owners to obtain abstraction licences, which in turn enables them to participate in the unofficial water market, diversifying production and securing a guaranteed, risk free source of income.

The operation of this unofficial water market identifies a number of problem areas which will potentially lead to unintended consequences and side effects if a tradable permit system is introduced. The unofficial water market developed in response to the demands of off-farm firms to acquire land with water rights attached. These firms are specialist growers and pre-packers who have access to significant reserves of non-agricultural capital. The involvement of these specialist commercial growers-prepackers in an official tradable permit system would raise significant questions of social equity and distributive justice. These firms, capitalising on their economic power, could outbid all other participants in the trading system and consequently water rights

would become concentrated in the hands of the few. Even if strict rules of entry are defined which prevent these firms from directly participating, it would be impossible to prevent farmers from acquiring water rights and subsequently leasing them out with the land to the commercial growers and pre-packers.

A tradable permit system would free water rights from land rights, and also increase the actual price of water. Although this would conform to the principles of economic efficiency it is by no means certain to ensure the protection of the *in situ* water environment, wildlife habitat or landscape features. In fact the rise in water prices would perpetuate a highly intensive system of agricultural production, in which farmers attempt to ensure a return on investment. Consequently, the area of land under highly intensive production could be extended, as land currently excluded from participation in the unofficial market, because of access to water, is converted to production of high value irrigated crops. This poses a number of critical environmental problems in inter-dependent economic and environmental systems, as problems are displaced from the water to the agricultural sector. Firstly, the reallocation of water rights will enable the conversion of land previously under grass or cereals to production of high value potato, carrot, onion and parsnip crops. This will have a marked impact on the landscape, particularly in an area such as the Brecklands which is a Government designated Environmentally Sensitive Area (ESA), where agencies such as English Nature, MAFF and local environmental groups are attempting to not only protect but also restore specific landscape features. Their ability to encourage farmer participation in these schemes will be severely undermined as they are unable to compete with the economic incentives associated with irrigated production. Secondly, the production of high value crops such as potatoes and root vegetables is also reliant on high levels of fertilisers, pesticides and herbicides in what is a highly intensive system of production. Thus, the risk of nitrate leaching and pollution of ground and surface water sources is high, particularly in the Lark and Thet-Little Ouse catchments, as the free draining sand land overlies chalk aquifers.

The introduction of an official trading system could also create additional problems for the *in situ* water environment within the catchment. In particular, the trading of sleeper licences could further exacerbate scarcity problems as unused licences of right maintain flow levels within the catchment. If these licences are traded and consequently brought into use, the down-stream river flow regime may alter dramatically and thereby undermine specific *in situ* water environments. There are also additional costs incurred through moving water, and these may discourage inter-catchment transfers. It is vital that the design and implementation of official tradable permit systems takes account of these displacement problems.

The analysis of farmers' irrigation decision making provides key insights into the processes likely to influence their response to a tradable permit system. Theoretically, trading should release the under- or un-used portions of farmers' licences for reallocation to other users and uses.

Nevertheless, this process will be critically influenced by the risk insurance strategies developed by farmers in order to avoid the threat of drought and abstraction restrictions. The analysis in section 6.1.2 demonstrates how farmers attempt to insulate themselves from the financial risks of producing poor quality produce, by reallocating water previously used on low value crops to their high value potato crops, even though the crop would never use all the water. In fact a total of 26 farmers claim that their total licence quantity incorporates a margin to enable them to irrigate their priority crops when 50% abstraction restrictions are imposed. Thus, the under-utilisation of water reflects the farmers' attempts to avoid the threat of unreliable supplies of irrigation water, and it is therefore unlikely that they would participate in the trading system as sellers of water rights.

The response of farmers to a hypothetical scenario involving a tradable permit system underlines this. Although 30 potato and vegetable farmers claim they would participate in the system, only 12 would actually sell all or part of their licence, while the remaining farmers would participate as buyers of water. In fact these 12 sellers of water include the 6 farms who stopped irrigation in the aftermath of the 1989-92 drought, and those 6 farms holding irrigation licence who don't, or never

have, irrigated. In consequence, the tradable permit system would only succeed in reallocating a small proportion of the unutilised water held by current licence holders, as there is a discrepancy between the large number of buyers and only a few sellers. However, an increase in the unit cost of abstraction water could change the whole equation as farmers are forced to critically re-evaluate their on-farm water use and risk insurance strategies, and consequently they may release surplus water for trading.

Mapping out the location of these potential buyers and sellers, as well as the untraceable and unused licences identified in table 4.4, within the catchments, provides a picture of the impact of trading on in-stream flow regimes, dependent flora and fauna and the potential for problem displacement. In the Bain-Witham catchment study areas, unused licences of right in the upper reaches of the catchments pose particular problems. These seven licences have either never been used, or irrigation has stopped in the last 5-10 years. Consequently, these licence allocations contribute to and maintain flow levels further down-stream, which is particularly important in the summer months to protect the *in situ* environment. The reallocation of this water through trading would have particularly negative impact, especially if the water is abstracted and used in the upper reaches of the catchment, thereby altering the flow regime further down-stream. Obviously, if the water is used in the lower reaches of the river this would not prove a problem, although the farmer would incur significantly higher water transfer costs.

Within both the Bain and Witham catchment study areas the transfer of water to potential buyers should prove relatively simple and cost effective, if the existing network of fenland drains and dykes is used to transfer the water. In contrast, the practicalities of setting up trading systems in the Lark and Thet-Little Ouse catchments could prove more difficult, as there is no extensive network of drains and dykes. This is further compounded by the fact that irrigation abstraction in these catchments largely utilise ground water sources. Consequently, there are two trading options, either the trading system would have to be confined to existing groundwater abstractors who have already

invested in borehole systems; or the water would have to be abstracted at the existing licensed bore hole site and subsequently transferred via an over ground pipeline or the river system. Obviously, the economic cost of transferring the water under these different options would be markedly different, and consequently may encourage only limited trading between neighbours where the costs would be lower. There would also be potential environmental problems associated with trading in ground water. In particular, if trading allows abstraction of under-utilised water from alternative bore hole sites in the catchment, this could indirectly affect in-stream river flow levels and wetland sites. Obviously, in the Thet-Little Ouse catchment this could pose particular problems for the protection of the Mere's environment. Tracing the impact of trading on the rate of aquifer recharge, river flow levels and wetland sites is an essential pre-condition to the implementation of a trading system.

The evidence suggests that farmers will fail to respond to the introduction of economic incentive measures in line with the postulates of rational economic person. A number of key processes critically shape their on-farm use and management of irrigation water and reflect the close inter-dependence between produce quality and irrigation. The analysis demonstrates how the perception and assessment of financial risk and uncertainty plays a pivotal role and over rides all other considerations in irrigation decision making. Consequently, farmers' response to demand management policies will appear somewhat confusing and contradictory, as a range of responses emerge. The analysis reveals how different groups of farmers, reflecting their differential incorporation into the quality projects of the down-stream food network, will respond differently to both incentive pricing of abstraction water and tradable permit systems.

Although both tradable permit and incentive pricing schemes may prove successful when measured against narrowly defined criteria of economic efficiency, and may conform to the postulates of economic sustainability, this analysis identifies a number of unintended consequences and side effects which will undermine the sustainability of inter-dependent economic and environmental

systems. In fact both incentive pricing of abstraction water and tradable permit systems may displace problems from the water sector to the agricultural sector, perpetuating a highly intensive system of production. The underlying premise of both forms of economic incentive measures, is the reallocation of water from low to high value crops, which by implication are more intensive systems of production. These systems of production are characterised by dependency on high levels of capital and labour inputs as well as high levels of nitrate, pesticide and herbicide usage. The increase in water price resulting under these schemes further contributes to the intensification of production, as farmers must recoup their increased costs. The analysis of the unofficial water market demonstrates this, with water reallocated for use on high value carrot, parsnip and potato crops, with the associated high usage of fertilisers, pesticides and herbicides. Consequently, the system contributes indirectly to the diffuse pollution of ground and surface water sources which poses particular problems on the flat sand land of the Lark and Thet-Little Ouse catchments, as the soil is particularly prone to leaching. The analysis also demonstrates how the unofficial water market contributes to the process of landscape change, loss of wildlife habitat and changes to catchment flow regimes. Hence, the implementation of economic incentive measures must proceed with extreme caution, as there is a real danger that these systems, while conforming to the principles of economic efficiency, will simply displace problems, creating far more complex environmental problems in inter-dependent economic and environmental systems for future peoples to deal with.

6.2: Negotiating access to reliable supplies of irrigation water: farmers' individual and collective response.

Chapter Four documents the limited role agricultural interests have played, shaping the direction of water policy, with Water Company interests dominating the allocation and regulation of water resources in the UK. Consequently, the drought of 1989-92 marks an important turning point, as policy makers and agricultural representative organisations came together to explicitly discuss irrigation issues for the first time. In fact, negotiations and representations emerge as the central mechanism through which farmers attempt to reduce their vulnerability to drought and abstraction

restrictions, and avoid the financial risks associated with producing poor quality produce. The ensuing negotiations and representations therefore provide critical insight into agriculture-state relations in the post-productivist era, revealing how the NFU, CLA and farmers themselves, respond to new and emerging environmental issues. Do these representative organisations revert to their traditional style of corporatist relations with the NRA, or are they forced to forge new relationships?

6.2.1: Conflict and change: The drought of 1989-92

The analysis in the previous sections of this chapter reveals the overriding importance of irrigation in the production of quality produce, and the management changes introduced by farmers in order to reduce their vulnerability to drought and abstraction restrictions. These adjustments in reality are only minor and do not in any way detract from the production of quality produce. The central mechanism through which farmers attempt to reallocate the risks associated with low rainfall and abstraction restrictions, is negotiation with the NRA to secure a reliable supply of irrigation water. This ensures that they avoid the financial risks of producing poor quality produce, as well as the financial costs associated with investment in water storage facilities or more efficient irrigation systems.

At the national and regional levels, there had been minimal contact between NFU, CLA and NRA representatives prior to the drought of 1989-92, with NFU officials recognising that water abstraction and irrigation policy had been a neglected area in the past (see section 4.1.3 for discussion of these issues). Consequently, this complicated the development of links and negotiations with the NRA regions during the drought years, with the NFU and CLA officials forced to establish new contacts and relationships. The reorganisation which was occurring in both the NFU regions and the water industry, with the establishment of the NRA, further compounded these problems. At the regional offices, the NFU designated one staff member responsibility for all liaison with the NRA over access to, and use of, water for spray irrigation. In addition to working on behalf of individual farmers in dispute with the NRA over spray irrigation, the official

was also responsible for putting forward the NFU policy line. Formal negotiations with the NRA were conducted at the regional level in 1991 after the imposition of abstraction bans under Section 45 of the 1963 Water Resources Act.

The absence of an established structure of communication between the NFU and NRA in part contributed to the conflictual response of farmers in the early years of the drought. The development of policy by the NFU at this time was largely reactive, as they failed to seize the initiative and put forward a coherent alternative to guide the implementation of abstraction restrictions at the local level. In fact, local initiatives resulting from direct negotiations between the NRA and farmers, played a key role during the drought years, and have critically shaped the development of NFU policy in the aftermath of the drought. This is revealed in the three catchment study areas, where three different styles of negotiation with the NRA are identifiable, reflecting the differential incorporation, of not only NFU and CLA personnel but also representatives from the vegetable pre-pack and co-op sectors, into negotiations and representations over access to, and use of, reliable supplies of irrigation water. These local initiatives attempted to ensure access to irrigation water, to prevent farmers incurring financial losses by producing crops of low quality and yield. In all cases the farmers attempted to ensure irrigation decision making remained under their direct control, and thus self-regulation through voluntary restrictions was favoured rather than the imposition of abstraction bans under Section 73 of the 1991 Water Resources Act.

1. The Bain - Witham Catchment

Negotiation with the NRA over access to, and use of, water in the drought of 1989-92 was primarily organised and managed by the local NFU branch secretary. In 1990 100% abstraction bans were imposed in the Bain - Witham with little or no warning,. Consequently the NFU secretary organised a meeting between farmers and representatives from the NRA Anglian Region head office, in order to ensure warnings were issued prior to the imposition of future abstraction bans. The primary objective of this initiative was to reduce uncertainty over the imposition of

abstraction restrictions, and thereby enable farmers to plan their use of remaining water supplies in order to maximise its benefit. This initiative laid the ground work for subsequent meetings in the 1991 season when the NRA, NFU and farmers in the catchment came together again early in the season. The probability of restrictions being necessary was high, and consequently the NRA, in conjunction with the local NFU secretary, developed a voluntary scheme whereby farmers were only allowed to irrigate one day in seven. These voluntary restrictions cut the farmers' total licensed quantity of water by 85%, but left their daily abstraction rate the same, enabling continued irrigation for a further 6 - 7 weeks before a 100% abstraction ban was imposed. This meeting also discussed the practicalities of policing the voluntary restrictions. Initially the NRA insisted all night time irrigation should stop, so they could police the voluntary restrictions effectively. However these proposals were heavily criticised by farmers as day time irrigation is deemed highly inefficient with water lost through both evapotranspiration and wind blow. The meeting finally persuaded the NRA to stop all day time irrigation, reducing the level of wastage as well as making enforcement of the system easier, as farmers found irrigating in daytime would automatically be fined.

The principal negotiations with the NRA were conducted by the NFU branch secretary with no individual farmer involvement. Representation by individuals with specific problems was made to the NFU branch secretary, who then talked with the NRA on their behalf. This total reliance on local NFU representations to the NRA stands in stark contrast to the other two catchment study areas where NFU officials had limited involvement in negotiations. This approach owes much to the local NFU secretary, who had developed close contacts with the RWA personnel over the previous 5 years. In fact, individual farmers relied on the NFU secretary to process all licence applications and renewals, and he also played a major role establishing negotiations with the RWA to address the high unmet demand for irrigation water in the western and eastern fen system. Protracted negotiations over a five year period involving the NRA (and its predecessor), the Internal Drainage Board (IDB) and the NFU culminated in the "Water Transfer Scheme", whereby

water is transferred from the river Trent , via the river Witham for abstraction in the western and eastern fen system. The NFU secretary played a critical role in these negotiations acting as the secretary for the scheme and, consequently this experience is perceived by the farmers as invaluable, in that it provided key insight into NRA administrative procedures and contact with key NRA officials in the area.

The NFU secretary was already established as the principal negotiator between farmers and the NRA over water abstraction in this area prior to the drought of 1989-92. There was an established channel of communication between farmers and the NRA over irrigation in which the NFU played a central role. This succeeded in dissipating the potential crisis over access to reliable supplies of irrigation water, as the NFU representative was able to quickly establish negotiations with the NRA. Although this did not prevent the imposition of restrictions in 1990, the NFU representative was able to capitalise on his position and use his influence to shape the design and implementation of subsequent abstraction restrictions. This proved critical as it re-established the principle of self-regulation, whereby farmers agreed to voluntary restrictions in order to ensure access to a proportion of their licensed water, and thereby reduce uncertainty over the imposition of future abstraction controls.

2. The Lark Valley

The summer of 1991 heralded the imposition of abstraction bans on irrigators using both surface and ground water sources as 50% and then 100% bans were imposed by the NRA. Hitherto, restrictions on ground water abstraction were limited, with surface water abstractors bearing the brunt of controls, as they were subject to 100% bans in the summer of 1990. Nevertheless, this experience did not provoke a response from farmers and it was not until ground water abstractors were also subject to limitations, that direct action was undertaken by farmers. In August 1991 all borehole abstractions within 2km of the river Lark were subject to 100% restrictions on irrigation use, and all other groundwater abstractors were restricted to 50% of their licence entitlement. In

direct response to the imposition of these restrictions, a meeting of all irrigators in the catchment was convened by the farmers themselves. The NFU and CLA were not involved in convening this meeting and all spray irrigation licence holders were included; thus orchards, garden centres and flower growers were represented as well as potato and vegetable farmers.

The agenda for this first meeting focused on developing a plan of action for negotiations and discussions with the NRA. Three key points were up for discussion: firstly, the procedures for implementing the ban by the NRA were a point of conflict and a number of farmers strongly argued in favour of legal action to claim compensation for loss of crop and income. The second key area of discussion revolved around the role of the NRA in granting licences to Cambridge Water Company to abstract water for transfer and use in Cambridge. This situation was perceived as inequitable, with farmers bearing the brunt of restrictions while industry and domestic consumers were unaffected. The continued use of water for low value “luxury” consumption such as garden watering and car washing was an important point of conflict, underlining the perception that the NRA had no understanding of on-farm irrigation use and the economic value of water to farmers. Finally, alternative procedures for allocating water in 1992 were considered vital if the drought continued, as it was deemed essential to ensure supplies to irrigators, to prevent further economic losses at the farm level and to protect dependent employment in the vegetable pre-pack and processing industries. The initial meeting met with a high response from abstractors and an official committee was sanctioned to negotiate with the NRA.

Although a number of the farmers argued strongly in favour of legal action against the NRA, the committee decided suing for compensation would be against their long term interests. The committee perceived that, on balance, they could not guarantee the positive outcome of any legal action, and possibly would only succeed in antagonising the NRA, creating difficulties for future licence applications and renewals. The approach that the committee adopted was therefore conciliatory, primarily focusing on re-educating the NRA on the role and significance of access to,

and use of, reliable supplies of water for irrigated agriculture in the catchment. The principal point of contact with the NRA were meetings held with the head of Anglian Region water resources section. A series of meetings at the end of the 1991 irrigation season sought to establish a simpler and more equitable procedure for the allocation of scarce water, if the drought continued into 1992. The critical issue for the committee was to ensure farmers knew, at the beginning of the season, if they would retain full use of their licensed water quantity over the subsequent growing season or if abstraction bans were likely. This enabled farmers to establish their priority crops at the outset of the season and thereby allocate water accordingly. The committee did not want the NRA determining water crop priorities and intervening directly in farmer decision making, as they strongly favoured farmers retaining full control over their irrigation decision making. In reality however this approach fails to recognise the difficulties encountered by the NRA in predicting with any certainty, the likelihood of restrictions, and therefore encourages them to adopt a very conservative approach.

After the initial meetings with the NRA, the committee accepted there was a water problem, affecting both river flow and water quality levels and consequently a set of proposals were put forward which accepted the principle of voluntary restrictions. The committee agreed a voluntary reduction of 40% of the farmers' total licensed quantity, so long as the NRA guaranteed the remaining 60% would be available for abstraction through the season. These calculations were calculated on the basis of national figures, which indicated only 60% of the total licensed quantity of irrigation water was actually used. Thus, in reality under these voluntary restrictions farmers would lose nothing. The NRA, although in agreement with the principle of voluntary restrictions, were unable to guarantee the water supply for the 1992 season or accept the 40% voluntary restriction figure, and consequently forced the committee to accept a 50% restriction.

These negotiations established a clear structure of communication between the NRA and spray irrigators in the catchment, and played a key role in diffusing the water/irrigation crisis.

Remarkably, the level of support for the abstractor committee was very high across all farmers interviewed in this catchment, with few dissenting voices against the committee line. The specialist flower, fruit and plant growers were closely involved in the group in order to ensure their interests were also represented in negotiations with the NRA, and the interests of the potato and root vegetable producers did not predominate. In the aftermath of the drought the committee still maintains links with the NRA, holding meetings at the beginning and end of the season to discuss the likelihood of future restrictions on water use. The committee recognises the importance of maintaining the momentum built up over the drought years, to ensure access to reliable supplies of water for agriculture remains a priority. Nevertheless, at the time of interview the committee had not commented on the Anglian Region's nor the National Water Resources' Strategies both published in 1994 (a + b) and had limited knowledge of the catchment management planning and catchment panel process.

The initial conflict between farmers and the NRA was clearly exacerbated by the absence of an established structure of communication between the NFU, CLA and NRA over the issue of water abstraction policy in the Lark Valley catchment. The failure of their official representatives to establish a channel of communication with the NRA resulted in the farmers themselves developing an independent water committee to negotiate collectively with the NRA. This grouping, with the full support of all irrigators in the catchment, became the principal forum for negotiations with the NRA. The initial response of farmers betrayed their ignorance and lack of understanding of water and the water regulators, as they adopted an adversarial stance. Nevertheless, initial discussions with the NRA succeeded in addressing these issues and underlined the critical water problem facing the catchment. Once convinced of the serious nature of the water problem, the farmers shifted their negotiating stance and adopted a conciliatory approach. The central factor shaping their approach was reducing uncertainty as well as preventing further financial losses through the unexpected imposition of abstraction restrictions and interruption of water supplies. Thus, the water committee drew on the principles of self-regulation and put forward voluntary restrictions and self-policing

measures in order to avoid greater intervention by the NRA in on-farm water management decision making.

3. The Thet - Little Ouse

Negotiation with and representation to the NRA over access to water for spray irrigation has proceeded on two principle issues in this catchment. Firstly, farmers entered into negotiations with the NRA over the implementation of abstraction bans during the drought years of 1989-92. The second, on-going area of discussion has emerged in the aftermath of the drought and revolves around NRA attempts to reduce the negative impact of drought on the Meres⁵ environment, through introducing cessation clauses into renewable licences.

The principal forum for discussions with the NRA during the drought period was the Peddars Way Group which is a former pea growers group made up of between 15 and 20 farmers in the Breckland area. Its primary role is to act as a collective forum for discussions with external agencies such as MAFF, ADAS and the PMB; 1991 was the first time discussions were held with the NRA over the issue of water for irrigation. The NFU and CLA were not directly involved in convening the group, but they were invited to attend the meetings with the NRA, where representatives from the four main vegetable and potato pre-packers in the area were present, and the meetings were chaired by the local M.P. Gillian Shepard, then Secretary of State for Employment. The first meeting was held in the summer of 1990, with the primary aim of ensuring 100% abstraction bans on spray irrigation were not imposed, or if bans had to be imposed, sufficient warnings were extended. Although at that stage there was no immediate threat of restrictions, the group was uncertain of NRA drought policy, and wanted to underline the vital importance of access to irrigation water not only to individual farmers but also to the local economy and dependent employment in the vegetable pre-pack sector. The group argued that they needed at

⁵ Meres are wetlands which occur when dips in the landscape intercept the water table. The Breckland Meres are SSSIs which occasionally dry out naturally; however under Section 57 of the 1991 Water Resources Act, the NRA is unable to use its statutory powers to impose restrictions on abstraction to protect this unique landscape feature.

least 2 weeks warning of an imminent abstraction ban, to enable them to plan their use of remaining water. In fact they suggested a blanket 50% cut in the daily abstraction rate was inequitable, as those with large licences would see little change in their actual daily usage and consequently argued strongly in favour of voluntary restrictions.

The vegetable pre-pack representatives played a central role in these discussions, underlining the importance of spray irrigation to their procurement of quality potatoes and root vegetables, and their customers the four main UK supermarkets. The key argument put forward by these vegetable pre-pack representatives concerned the impact of abstraction restrictions on the quality of produce and the knock-on effects for employment. Company representatives also argued their inability to guarantee a continual supply of quality vegetables would lead their main customers, the supermarkets, to switch their procurement strategy to overseas suppliers, and contribute to the on going balance of payments deficit. These negotiations culminated in the agreement of voluntary restrictions whereby farmers within a 5km radius of the Meres accepted a 50% reduction in their licensed abstraction.

In the post-drought period the NRA has been in discussions with farmers, within a 5km radius of the Meres, over the introduction of cessation clauses⁶ into renewable licences. Eight farmers are directly affected by these proposals and have held group meetings with the NRA to discuss them, with no NFU or CLA involvement. Their principal argument against the imposition of cessation levels is the increased uncertainty introduced into farm irrigation decision making. Restructuring crop management strategies would be forced onto these farmers and all of them argued that their potato and root vegetable acreages would have to be cut, as they are unwilling to incur the financial losses resulting from poor quality produce. The approach adopted by these farmers is conciliatory, as they argue for the introduction of voluntary restrictions rather than cessation levels. Cessation

⁶ The cessation clauses are calculated by the NRA and once river flow levels drop below a certain defined point all abstraction will have to stop. There would be no warning and no scope for negotiation, simply a 100% cut in water abstraction.

levels are perceived in wholly negative terms, allowing no room for negotiation or discussion with the NRA. Although the farmers recognise the advantages of entering into discussions with the NRA, if they fail they are quite prepared to legally challenge the licence renewal, resulting in a Public Enquiry.

These negotiations are further complicated in the farmers' minds, by the fact that discussions over cessation levels are not conducted solely with the NRA but involve English Nature and other environmental bodies. These groups are perceived in wholly negative terms and as a greater threat to on-farm water management strategies than the NRA. The farmers perceive the attitude of the NRA as conciliatory and are wrongly convinced that if cessation clauses are introduced they would not police them rigorously. Environmental groups, however, are perceived as the wreckers of such a relationship, forcing the NRA to rigorously police the cessation levels by threatening legal action. The negotiating strategy of these farmers focuses exclusively on discussions with the NRA, and at the time of interview no talks had been held with English Nature or other environmental groups active in the area.

Although the NFU and CLA were not directly involved in negotiations with the NRA in the pre- or post- drought period, the farmers succeeded in presenting a strong case, by involving not only their local MP, but also local specialist growers and pre-packers. By not presenting the issue solely in terms of the impact on individual farmers, but in terms of the knock-on effects for employment and the rural economy, they were able to broaden the scope and incorporate other actors into their collective negotiations. This is in marked contrast to the approaches adopted in the other two catchments, where actors from the down-stream food network were not invited, let alone incorporated into collective negotiations with the NRA. In part this reflects the vital role of these growers-prepackers in the catchment, where they also irrigate their own and others land, and thus have a direct interest in retaining access to reliable supplies of water. Self-regulation and voluntary restrictions were once again the key principles shaping the collective negotiations, as the group

attempted to prevent the unexpected imposition of restrictions. They were also in the fortunate position of the NRA being unable to use its statutory powers to impose restrictions to protect damage to the Meres environment, thus they were forced to negotiate, to minimise the damage on these specific environmental sites.

Despite differences in the actual structure and organisation of negotiations with the NRA, the approaches adopted by the farmers in the three catchment study areas were remarkably similar. The three groups all asserted the principles of self-regulation, through voluntary restrictions in order to stop the NRA from imposing further official restrictions. Their overriding objective was to reduce uncertainty over access to irrigation water and thereby prevent further financial losses. Although these negotiations all culminated in the same outcome, the actual processes of negotiation were markedly different, and reflect tensions within the traditional corporatist relationships which dominate agriculture-state relations.

The analysis reveals how the failure of both the NFU and CLA to establish a clear network of communication with the NRA, at both the local catchment and regional level, over the issue of irrigation use, culminated in the crisis response to the drought of 1989-92. This in part reflects their ignorance of water abstraction issues, and the importance to farmers of retaining access to and use of reliable supplies of irrigation water. This had not been a “traditional” area of lobbying by the NFU and it was therefore marginalised in negotiations with the NRA (and its predecessor) as flood defence and latterly pollution control took precedence. The misperception that irrigation water is an agricultural issue reflects their failure to respond positively to new and emerging environmental issues. This left a critical gap, and in the drought of 1989-92 local farmer groups developed to fill the policy vacuum. Consequently, the NFU and CLA were by-passed, as local initiatives were developed to negotiate directly with the NRA. The ensuing negotiations reflect, not only the ignorance and misconceptions surrounding water issues found among farmers and their representative groups, but also the failure of the NRA to recognise the importance to farmers of

access to and use of reliable supplies of irrigation water, and their ignorance of the practicalities of irrigating on the farm. The fact that farmers in the Bain-Witham catchment had already established a structure of communication with the NRA was a key factor preventing the “crisis” response which predominated in the Lark and Thet-Little Ouse. Despite this initial response, farmers in these two catchments subsequently established negotiations with the NRA to secure reliable supplies of irrigation water. Actors from off the farm were also incorporated into these negotiations, as firms from the down-stream food network became involved in discussions in the Thet-Little Ouse catchment. However, there was no close involvement from the supermarkets and processors, as their arms length control of production enabled them to distance themselves from local environmental conflicts. The success of these groups is attributable to their command over their constituencies, as they were able to ensure all farmers complied with the voluntary restrictions. Thus, the principles of self-regulation were of central importance, as groups drew on them in their negotiations with the NRA, even though the NFU and CLA were not involved.

In the aftermath of the drought, the NFU and CLA have reasserted control at the national and regional policy levels, and have played a key role, directly and indirectly influencing both the design and implementation of Government and NRA policy on water regulation. Their success is reflected in the concessions to agricultural interests included in the 1995 Environment Act noted in Chapter Four, and the formation in 1995 of the National Water and Agriculture Forum in which representatives from MAFF, EN, NFU and CLA discuss irrigation issues. These organisations are also taking the lead in the debate on demand management policies in the agricultural sector, with the NFU, in particular, publishing a number of policy discussion documents (Naish 1994; Smyth 1995; NFU 1996). Thus, having established a clear structure of communication with the NRA, the NFU and CLA will undoubtedly exert a powerful influence in the future policy debate over the design and implementation of demand management policies.

The initial response of farmers and their representative organisations to the drought of 1989-92, reveals the problems encountered when confronted with new and emerging environmental issues. The analysis demonstrates the central importance of social forces of regulation in influencing not only the design and implementation of abstraction restrictions, but also ensuring compliance with the restrictions amongst irrigators themselves. The role of the NFU and CLA in these discussions however, was minimal, as new independent groups emerged to negotiate directly with the NRA. The breakdown of the traditional form of negotiation between agriculture and the state reflects the failure of the NFU and CLA to recognise the importance of irrigation issues to agriculture and they were therefore slow in reacting to local level problems. This, however, should not imply the emergence of new forms of corporatism in the agricultural sector, as the NFU and CLA have subsequently reasserted their influence and are playing a central role in the policy debate on demand management policies.

6.3: Conclusion.

Farmers enmeshed in the agriculture-water interface are subject to a plethora of competing and conflicting signals emanating from the NRA, now the Environment Agency, and the down-stream food network. There is little integration or engagement between these two networks of state and market regulation, with farmers at the local level, the focal point for these divergent forces, forced to negotiate between, and reconcile these conflicting and contradictory signals in order to formulate effective farm management strategies. Nevertheless, these are not separate or discrete areas of farm decision making and are in fact closely inter-twined. Access to, and use of, reliable supplies of irrigation water are central to farmers' engagement with the quality projects of the down-stream food network and this process of interaction, in turn, critically shapes and reshapes their negotiations and representations with the Environment Agency. This analysis demonstrates how a combination of regulatory forces together shape the on-farm use and management of irrigation water. The sustainability of the agriculture-water interface can only be assured if a new, alternative

approach to environmental regulation is adopted which promotes synergy between the plethora of regulatory signals shaping the production and consumption of food.

CHAPTER SEVEN

CONCLUSION

REGULATING THE AGRICULTURE-WATER INTERFACE: THE WAY AHEAD

Realigning development at the agriculture-water interface along a sustainable pathway will not be amenable to simple or unequivocal solutions. Policy integration will have to overcome the complex economic and environmental inter-dependencies which displace problems from one media, time or place to another. This final chapter will draw together the various strands of analysis, and attempt to pin point the critical implications not only for the theoretical debate on nature and society, but also the key issues for environmental policy. The discussion will be presented in two sections; the first section will concentrate on the theoretical debate and will re-examine the six theoretical postulates identified in Chapter Two. The analysis will evaluate the explanatory value and significance of these postulates to understanding the complex processes underpinning the inter-sectoral transfer of environmental problems. The second section will focus on the implications for both the design and implementation of environmental policy in general, and the introduction of demand management policies in the agricultural sector in particular, drawing out the specific policy recommendations for the Environment Agency.

7.1: The agriculture-water interface: the theoretical contribution.

The multiple and conditional hypotheses identified in Chapter Two address the complex processes which together contribute to the dynamic displacement of environmental problems at the agriculture-water interface. The postulates address different dimensions of the complex interplay between market, state and social forces of regulation in order to trace the implications for irrigation use and the water environment. Although no one theoretical postulate provides a holistic framework of analysis, it is possible to distinguish specific theoretical postulates which are central to understanding specific dimensions of the dynamic displacement process. Firstly, it is critical to recognise that environmental problems are characterised by both market and state failures, with the

current abstraction charging and licensing systems conforming to classic market failures (Tietenberg 1992; Pearce *et al* 1989) while the problems of low flow rivers and over- abstracted catchments confirm the central role of inappropriate state intervention in creating many of the world's environmental problems (Janicke 1990; Andersen 1994). Inappropriate Government intervention perpetuates the dynamic displacement of environmental problems by focusing policy solely on technocratic policy prescriptions, which do not address the underlying causes of the problem. Consequently, policies focusing solely on redefining property rights to the environment or designing the optimal pricing schemes in line with the postulates of neo-classical environmental economics, will perpetuate the dynamic displacement of environmental problems if they fail to address the political and institutional context within which the regulated are situated.

The limitations of the purely sectoral approach to policy are revealed by drawing on the political economy tradition which exposes the complex network of social relations within which the regulated are situated. The analysis reveals the relations of power and dependence which link farmers at the local level with the regional, national and international market, state and social forces of direct and indirect regulation. Tracing the forces of regulation which directly and indirectly control and manipulate decision making at the individual level is central to understanding the key forces which undermine and distort the response of the regulated to specific environmental policies and the unintended consequences and side effects which result. This approach reveals the central importance of market forces of regulation in shaping the use and management of irrigation water at the farm level.

This is complemented by the theory of the firm, which is central to understanding the form and function of market regulation. Although interaction between firms is underpinned by complex relations of power and dependence, this only partially explains the combination of processes at work, as the analysis demonstrates how firms successfully regulate each other's behaviour. Contrary to the profit maximisation thesis of traditional neo-classical economics, the analysis

reveals the central role of risk minimisation goals in shaping interaction not only between firms, but also between firms and farmers. As postulated in the behaviouralist theory of the firm (Crew 1975) and in recent studies in economic geography (Ekinsmyth *et al* 1995), promoting certainty and stability within the firm is of paramount importance. Firms in the fresh and processing food networks are responding to the financial, production and legal risks and uncertainties associated with the production and consumption of food. The analysis documents how supermarkets are re-defining the form and function of their inter-relationship with subordinate firms in order to avoid the legal and financial risks associated with non-compliance with BS5750. In line with the postulates of Balch and Wu (1974) and Crew (1975), the analysis demonstrates how firms, reducing the risks and uncertainties attendant on their own production environments, succeed in reallocating risk to subordinate firms and farmers. By controlling production at a distance, the supermarkets and processors avoid incurring any of the financial or production risks and uncertainties associated with land ownership, and are divorced from the impact of their decision making on the environment.

The analysis traces the specific consequences of the strict produce variety and quality criteria for the use and management of irrigation water and the water environment, revealing how these forces of indirect market regulation fuel the demand for irrigation water. Despite this close inter-linkage, none of the firms in the downstream food network conceptualise water as an environmental issue, and fail to recognise the impact of their quality specifications on irrigation use at the farm level. The analysis confirms the postulate of the behaviouralist work on risk and uncertainty, by underlining the central role of information in shaping the perception and assessment of environmental risk and uncertainty (Dasgupta 1982; Segersen 1992). Complete ignorance of water issues at all levels of the fresh and processing networks explains the poor perception of water as an environmental issue. In fact, the analysis refutes the contention of Casson (1982) that unequal access to information within the firm shapes the response to environmental issues, by revealing that no other individual or department is accorded responsibility for water issues. Consequently, lack of information is a critical barrier to change.

The theory of the firm, and behaviouralist literature on risk and uncertainty, are essential to understanding the form and function of market forces of regulation and the nature of interaction between firms. These literatures are also drawn on to expose the black box of farmer decision making processes, in order to understand the complex trade-offs calculated as they negotiate between, and reconcile, the competing demands of state and market forces of regulation. The analysis identifies the critical gaps in farmer knowledge and understanding of water, water rights and the water environment. Confirming the postulate of the behaviouralist work on risk and uncertainty, the analysis reveals the central role of individual knowledge and experience in shaping farmer perception of water as an environmental issue. Although this may in part explain the failure of farmers to respond to environmental risks and uncertainties associated with irrigation use, the analysis demonstrates the overriding importance of financial risk and uncertainty in shaping on-farm irrigation decision making.

Irrigation use is inextricably inter-twined with the production and marketing of quality produce, and the analysis demonstrates the significant financial losses incurred through failure to meet the quality specifications. Farmers, therefore, attempt to minimise these risks by instigating intensive irrigation programmes at the farm level. Economic self-interests predominate, and the analysis reveals how the introduction of changes in the management and use of irrigation water, have been implemented with the primary objective of insulating the farm from the impact of drought and abstraction restrictions. Farmers are responding to the forces of market regulation and co-ordinating production, in order to ensure the quality of produce. Consequently, farmers' irrigation decision making in response to demand management policies, cannot be dismissed as irrational if they fail to respond to water price rises in line with the postulates of "rational economic person". In fact, in the context of their interaction with the downstream food network and risk minimisation goals, farmers' behaviour must be seen as perfectly rational.

The dynamic displacement of environmental problems from one media, time or place to another is not a simple, uni-dimensional process and it is impossible to pinpoint one specific mechanisms which is the sole contributing factor. In reality, a combination of processes together underpin the perpetual transfer of environmental problems, although the specific configuration of processes is unlikely to be the same in all areas of environmental conflict. This analysis of the agriculture-water interface reveals that the dynamic displacement of environmental problems from the water to the agricultural sector and vica versa, does not result solely from inappropriate Government intervention or market failures. The reality is far more complex, and reflects the contradictory interplay between economic, social, political, institutional and environmental processes which together perpetuate the cross-media transfer of environmental problems.

7.2: The agriculture-water interface: implications for environmental policy and practice.

Radical reappraisal of the form and function of environmental policy is a vital prerequisite to ensure the sustainable development of the agriculture-water interface. Rectifying the dynamic displacement of environmental problems is of paramount importance, in order to break the perpetual cycle which transfers problems from one media, time or place to another. A number of key policy recommendations emanate from the analysis which address this issue, and suggest an alternative agenda of action for the Environment Agency. Although these relate specifically to the implementation of demand management policies in the agricultural sector, the principles which underpin these recommendations are also more widely applicable to the debate on environmental policy and management. This does not imply a return to the sterile debate on the relative costs and benefits of alternative tools of environmental regulation, encompassing direct command and control, or economic incentive measures. The discussion transcends these issues, as the implementation of any of these alternative tools of environmental regulation will, in fact, perpetuate the displacement of environmental problems, without more radical reform of the actual policy process. In order to ensure the integration of the environment and economy, intervention

must be redirected away from a purely sectoral approach, to ensure the combination of regulatory forces impinging on resource decision making work in synergy rather than dissonance.

7.2.1: An inter-sectoral policy approach.

The first step in this alternative approach is the recognition that environmental policy does not exist in a vacuum; a plethora of other state, market and social forces of regulation directly and indirectly shape and influence the decision making of the target population. In consequence, their response to specific environmental policy initiatives cannot simply be read off, as they will be critically influenced by the other forces of regulation which directly and indirectly impinge on their decision making. In reality these other forces of regulation conflict with or contradict, the environmental policy signal and distort the response of the regulated, leading to unintended consequences and side effects. Given this regulatory dissonance, it is both inefficient and ineffective to confine state environmental policies solely to redirecting the behaviour of individuals at the local level. Their power to effect change is severely circumscribed, as they are locked into a complex network of social relations which directly and indirectly controls and manipulates their production and consumption decision making. It is therefore, vital to realign these forces to ensure they work in synergy and relay a co-ordinated message to individuals at the local level.

This does not imply the simple redirection of state policy intervention or the targeting of policies to other sectors of the economy. Harnessing the power and influence of market and social forces of regulation, necessitates an alternative, proactive approach. The environmental regulator must work with both trade associations and individual firms to realign the forces of market and social regulation. Recognising firms are locked into a complex network of inter-relations, in which some firms exploit their positions of economic power to control and manipulate the flow of information and capital to subordinate firms, it is possible to focus attention on these dominant firms and build upon their existing framework of inter-firm regulation. Thus, the environmental regulator could concentrate advice to specific firms on the principles of eco-labeling or environmental auditing.

These schemes would be implemented and policed by the firms themselves as they incorporate eco-labels or environmental audits into supplier contracts. The scope of this alternative approach is clearly elaborated through the analysis of the agriculture-water interface.

7.2.2: An alternative agenda of action for the Environment Agency.

A combination of regulatory forces are pushing and pulling farmers in competing and conflicting directions critically distorting their use and management of irrigation water and leading to unintended environmental consequences and side effects. The analysis documents the central role played by market forces of regulation, as supermarkets, food manufacturers and processors directly and indirectly manipulate on-farm production decision making, through the specification of strict produce quality criteria. Tracking farmers' incorporation into these quality projects, reveals how the strict produce quality criteria for potatoes, coupled with the susceptibility of the preferred varieties to both drought and common scab, force farmers to instigate an intensive regime of irrigation. The overriding importance of produce quality and the limited power of farmers to resist the quality dictates of the downstream food network, distort the impact of other forces of state, market and social regulation. The implications for demand management policy and the environment are exposed in this analysis.

The application of the principles of demand management in the agricultural sector, focuses on five key areas of change encompassing economic incentives, changing irrigation technology, switching production to drought tolerant crops or varieties, changes to the actual land tillage methods to reduce run off and wastage, and the construction of water storage facilities. These changes are principally targeted at farmers, and fail to recognise the complex web of interdependencies which critically influence and shape their use and management of irrigation water. In reality, farmers will fail to respond to these policy measures in the theoretically optimal manner, as the analysis clearly reveals their limited power and influence over production decision making. The willingness and ability of farmers to switch to drought tolerant crop varieties is severely circumscribed, as they are

tied to the production of the preferred potato varieties designated by the supermarkets, crisp and chip processors. The power of farmers to resist the quality and variety specifications of the downstream food network is limited, as these firms dominate the UK potato market and there are only a restricted number of alternative outlets for produce.

Focusing on the response to economic incentive measures, principally incentive pricing of abstraction water and tradable permit schemes, the analysis reveals how even under the current abstraction charging scheme, irrigation on some farms is already uneconomic, and these farmers would be better off switching to the dry farming option. The short and long term gross margin analysis demonstrates that the response to LMC pricing is likely to vary dramatically, reflecting farmers' differential incorporation into the quality projects of the downstream food network. The rise in water abstraction prices to the £225 level should prove sufficient to shift the behaviour of small, family farmers irrigating relatively small areas of potatoes. Although this process of change may not be immediate, these farmers would be forced to critically reassess their irrigation use when faced with a decision on the replacement or repair of irrigation equipment. Higher annualised costs of investment, combined with a water price of £225 per megalitre, should trigger movement out of irrigation. In contrast, the impact of water price rises on large, water and capital intensive potato producers will prove more complex. The analysis demonstrates how these farmers still incur significant financial losses from moving out of irrigation, when the alternative water costs are included. Thus, price increases to the £225 level may simply be absorbed, so long as farmers are still able to consistently produce the high quality potatoes with the attached price premiums. However, this situation changes markedly if farmers are forced to accept lower potato prices because of quality problems. Hence, farmers' perception and assessment of financial risk and uncertainty will play a central role shaping their response, and the rise in water price to the £225 level may encourage the construction of water storage facilities, even on the flat sand lands of Norfolk and Suffolk.

The response of farmers to a tradable permit system is no less complicated. Although the analysis identifies the potential for reallocating under- or un-used licensed water in the three catchment study areas, it also reveals how these schemes will perpetuate an unsustainable system of agricultural production. Detailed analysis of the informal water market in the Breckland study area identifies the potential problem areas. Under- or un-utilised portions of abstraction licences are leased with land rights for use on a short-term basis by commercial growers and pack houses, for the production of high value carrot, parsnip and potato crops. Short-term leasing of land and water rights has enabled these firms to extend production; however this is a highly intensive system of production which is dependent on high levels of chemical inputs, and there is a high risk of pollution of ground and surface water sources. The conversion of land to these high value crops contributes to the process of landscape change and habitat loss. In an Environmentally Sensitive Area (ESA) such as the Brecklands, the informal water market conflicts with the attempts of MAFF and English Nature to protect this unique landscape and environment.

Detailed scrutiny of the informal water market demonstrates the willingness of farmers to reassess their irrigation use in response to higher water prices, as they reallocate under- or un-used water from low to higher value crops, thus confirming the predictions of economic theory. Nevertheless, wider participation in formal trading schemes will be critically influenced by the risk insurance strategies designed by farmers to avoid the threat of drought and abstraction restrictions. The analysis demonstrates how farmers' total licensed quantity of water incorporates a margin, to enable them to irrigate priority water crops when 50% abstraction restrictions are imposed. Consequently, these farmers are unlikely to release their under-utilised water and participate in a trading system as sellers of water rights. In fact, the response to the hypothetical tradable permit scenario reveals the discrepancy between the large number of buyers and only a few sellers. Over coming these risk insurance strategies will prove critical in ensuring the efficiency and efficacy of trading schemes.

Although the farmers' response to tradable permit systems would conform to the principles of economic efficiency and ensure the reallocation of water from low to high value uses, it is clear that it will also succeed in transferring problems to the agricultural sector. Both forms of economic incentive measures will perpetuate and allow the extension of a highly intensive system of agricultural production. This contributes to the loss of both landscape and wildlife habitat, the diffuse pollution of ground and surface water sources, alteration of the flow regime within catchments and thereby undermines the sustainability of the *in situ* water environment. These policy tools will create far more complex environmental problems, which are displaced from the water to the agricultural sector.

Focusing on the interaction and interplay between the combination of state, market and social forces of regulation, exposes the conflicting and contradictory processes which influence farmers' response to specific demand management policies. These responses, or non responses, cannot simply be dismissed as irrational, as the analysis reveals how, in the context of their interaction with market forces of regulation, farmer's irrigation decision making is in fact rational. The forces of direct and indirect market regulation successfully penetrate on-farm production decision making and in consequence dominate irrigation decision making, resulting in an intensification of water use at the farm level. The efficacy of demand management policies focused solely on farmers is therefore brought into question, as these policy measures fail to nullify the signals emanating from the downstream food network. Only through realigning these forces of market regulation will the sustainable development of irrigation water and the environment be assured.

Redirecting state policy intervention away from just farmers and targeting key players in the downstream food network will remove the key source of dissonance which undermines and distorts the work of the Environment Agency. Harnessing the power of the downstream food network will ensure the different forces of regulation work in synergy, and thereby promote a co-ordinated approach to farmers at the local level. The analysis in Chapter Five identifies three key areas of

change which harness the existing resources of firms in the downstream food network and focus on their research and development programmes, investment in water storage and alternative irrigation technology and the reform of the produce quality specifications.

The processors and major potato pack house companies already have well established research and development programmes into alternative potato varieties and techniques of potato production.

Harnessing these resources to direct research into alternative potato varieties which are tolerant to both drought and common scab would, over the long term, have a major impact on the demand for irrigation water at the farm level. Secondly, although the downstream food network has traditionally resisted direct investment in agriculture, firms which issue forward production contracts to farmers could provide finance for investment in water storage facilities, particularly where contract farmers are concentrated in relatively small geographic areas. This would encourage the construction of collective reservoirs, thus reducing the cost for individual farmers, alleviate the pressure on water resources in the summer months and insure the protection of particularly sensitive water environments. The off-farm firm would also benefit through reduced uncertainty over the consistent supply of quality potatoes, as the farmers would have a guaranteed supply of water to apply throughout the season. The off-farm firms could partially finance the investment and act as a financial guarantor or co-ordinator so that groups of farmers could finance investment themselves. This would clearly have a major impact primarily in areas where the cost of reservoir construction is high, such as the Lark or Thet-Little Ouse catchments where the flat sand land provides few cheap, natural reservoir sites.

The third key change involves the relaxation of the produce quality specifications particularly in relation to potato skin finish, which would have a major impact on the use of irrigation at the farm level. The supermarkets, by increasing their tolerance to the incidence of common scab, would enable farmers to relieve the intensive programme of irrigation in the early stages of the season. This would bring to an end the wasteful use of water, which merely ensures the appearance of the

potato and does not in any way contribute to improvement in the size or taste. Finally the downstream food network could play a central role reinforcing the Environment Agency's message on the wise use of water. The principles of demand management and water conservation could easily be incorporated into the information booklets and advice provided to farmers by these firms. In combination, these initiatives would have a profound influence on the on-farm use and management of irrigation water and would contribute to the de-intensification of irrigation use. Action to protect the environment by the downstream food network is not unprecedented, as supermarkets and processors are already responding to the agricultural pollution problem, through the Integrated Crop Management (ICM) scheme and research into alternative potato varieties. Nevertheless, a major impediment to this proactive approach is the significant level of ignorance among managers in the downstream food network of water resource management issues. The analysis reveals the critical gaps in their knowledge of water, irrigation and the environment, and their complete failure to conceptualise water as an environmental issue.

The Environment Agency must therefore adopt an alternative role to ensuring the sustainable development of water resources in the agricultural sector. Rather than simply directing policy solely to farmers at the local level, the Environment Agency must instigate a wider programme of action directed to all levels of the food network, including supermarkets, processors, trade associations and the consumer. The first step of this alternative approach should focus on a programme of education underlining the problems confronting the Agency as it attempts to reconcile the competing demands for water from industry, agriculture and domestic users while at the same time ensuring the protection of the *in situ* environment. Having firmly established the nature of the resource problem, the Environment Agency, in tandem with the NFU and CLA, should explicitly identify the implications of drought and abstraction restrictions for farmers and their production of fresh fruit and vegetables. The role of the quality projects in fuelling the demand for irrigation water should also be examined. Having clearly addressed the information gap which underpins the poor perception of water as an environmental issue, firms in the downstream food network should be

receptive to a more pro-active role. Changes implemented by these firms will prove critical as the sustainable development of water resources and the environment will only be assured if the signals emanating from State, market and social forces of regulation work in synergy rather than dissonance.

This analysis has explored the central dimensions of the agriculture-water interface, exposing the conflict of interests and values which underpin the allocation and regulation of water in the agricultural sector. These conflicts and contradictions will become more sharply drawn as the debate on demand management shifts, to consider the actual design and implementation of policies. Additional research, to input into this debate, is essential to ensure the transparency of all the economic, social, political, institutional and environmental costs and benefits associated with the range of alternative policy options. Prior to the introduction of economic incentive measures, pilot schemes should be implemented, to critically assess their feasibility and potential impact. Careful consideration should be given to the role of “sleepers” licences, and the potential impact of trading them on the environment. The resources allocated in these licences may currently be supporting in-stream flow levels and pollution dilution processes, and trading may exacerbate these problems. Research on farmer knowledge and understanding of water, water rights and the environment should also be extended, to include those currently not irrigating. The behaviour of this group of farmers, as potential buyers of water rights, may critically distort the efficiency and efficacy of tradable permit schemes, raising questions of social equity and distributive justice. As this analysis demonstrates, the sustainability of inter-dependent economic and environmental systems should form the corner stone of environmental policy assessment, to ensure policy intervention does not result in the development of more intractable environmental problems.

References

- Advisory Council for Agriculture and Horticulture in England and Wales (1980) Water for Agriculture: Future needs, DoE, MAFF: London
- Andersen, M.S. (1994) Governance by green taxes: Making pollution prevention pay, Manchester University Press: Manchester
- Anderson, T.L. (1986) The market alternative for land and wildlife pp 41-56 The Heritage Foundation (ed) Protecting the Environment: A free market strategy, The Heritage Foundation: Washington D.C.
- Arrow, K. (1971) Essays on the theory of risk bearing, Markham Publishing Co.: Chicago
- Auld, D.A.L. (1985) Equity and equivalence: Aspects of effluent and output taxes International Journal of Environmental Studies vol. 24, no. 1
- Ayres, I., Braithwaite, J. (1992) Responsive regulation: Transcending the deregulation debate, Oxford University Press: Oxford
- Baden, J., Stroup, R.L. (eds) (1981) Bureaucracy vs. environment: The environmental costs of bureaucratic governance, The University of Michigan Press: Ann Arbor
- Bailey, R. (1990) Irrigated crops and their management, Farming Press: Ipswich
- Bailey, R. (1993) Irrigation equipment selection and management pp23-32 in Bailey, R. (ed) Irrigating potatoes, UK Irrigation Association Technical Monograph no.4
- Balch, M., Wu, S. (1974) Some introductory remarks on behaviour under uncertainty pp1-22 in Balch, M., McFadden, D., Wu, S. (eds) Essays on economic behaviour under uncertainty, North Holland Publishing Co.: Oxford
- Bate, R.N., Dubourg, W.R. (1995) A net-back analysis of water irrigation demand in East Anglia CSERGE Working Paper WM 95-01 University of east Anglia: Norwich
- Bates, S., Fearn, A., Wilson, N. (1996) Factors affecting the marketing of UK potatoes: Results of a survey of UK potato growers Farm management vol. 9, no. 5, pp 240-250
- Baumol, W., Oates, W. (1975) The theory of environmental policy, Cambridge University Press: Cambridge
- Baumol, W.J. (1968) Entrepreneurship in economic theory American Economic Review(Papers and Proceedings) vol. 58, no. 2, p 64-71
- Beardall, C.H., Harding, M., Holmes, N., Condor, A. (1992) Water for wildlife: a review of water resource management issues in the Anglian region, R.S.N.C.: Anglian Wildlife Trusts
- Beck, U. (1992) Risk Society: Towards a new modernity, Sage Publications: London

- Bennington, G. (1994) New developments in irrigation: Field scale trickle, Irrigation News no. 23, pp 3-8
- Benton, T. (1994) Biology and social theory in the environmental debate pp 28-51 in Redclift, M., Benton, T. (eds) (1994) Social theory and the environment, Routledge: London
- Berle, A.A., Means, G.C. (1932) The modern corporation and private property, Harcourt Brace: New York
- Blaikie, P. (1995) Changing environments or changing views? A political ecology for developing countries Geography vol. 80, no. 3, pp 203-214
- Blaikie, P., Brookfield, H. (eds) (1987) Land degradation and society, Methuen and Co.: London
- Boswell, J. (1973) The rise and decline of small firms, Harper Collins Publishers Ltd: London
- Bowers, J. (1995) Sustainability, agriculture and agricultural policy, Environment and Planning A, vol. 27,xc, pp 1231-1243
- Bremer, M. (1987) Intensive interviewing pp 147-162 in Bremer, M., Brown, J., Canter, D. (eds) The research interview: Uses and approaches, Academic Press: London
- Bromley, D.W. (1991) Environment and economy: Property rights and public policy, Blackwell: Cambridge, Ma.
- Bryant, R.L. (1992) Political ecology: An emergent research agenda in third world studies Political geography vol.11, no.1, pp12-36
- Bryman, A., Burgess, R.G. (eds) (1994) Analyzing qualitative data, Routledge: London
- Burton, I.R., Kates, W., White, G.F. (1978) Environment as hazard, Oxford University Press: New York
- Callon, M. (1986) Some elements of a sociology of translation: Domestication of scallops and fishermen of St. Brieuc Bay pp 196-233 in Law, J. (ed) Power, action and belief: A new sociology of knowledge, Routledge: London
- Casson, M. (1982) The entrepreneur, Martin Robertson: Oxford
- Cawson, A. (1977) Environmental planning and the politics of corporatism Working papers in Urban and Regional Studies, no.7, University of Sussex: Brighton
- Cerny, P.G. (1990) The changing architecture of politics: Structure, agency and the future of the state, Sage: London
- Cerny, P.G. (1991) The limits of deregulation: Transnational interpenetration and policy change European Journal of Political Research vol.19, no.2/3, pp 173-196
- Chandler, J. (1994) Integrated catchment planning Journal Institute of Water Engineering Management vol. 8, no. 2, pp 93-96

- Ciriacy-Wantrup, S.V., Bishop, R.C. (1975) Common property as a concept in natural resource policy Natural Resources Journal vol. 15, no. 4, p713-727
- Clark, G.L. (1992) 'Real' regulation: The administrative state Environment and Planning A vol. 24, pp 615-627
- Clark, J., Lowe, P. (1992) Cleaning up agriculture: Environment, technology and social science Sociologia Ruralis vol.xxxii, no. 1, pp11-30
- Clunies-Ross, T. (1990) Organic food: Swimming against the tide pp 200-214 in Marsden, T., Little, J. (eds) Political, social and economic perspectives on the International food system, Avebury:Aldershot, England
- Coase, R.H. (1960) The problem of social cost Journal of Law and Economics vol.3, pp1-44
- Colby, B.G. (1989) Estimating the value of water in alternative uses Natural Resources Journal no.29
- Conway, G., Pretty, J. (1991) Unwelcome harvest: Agriculture and pollution, Earthscan: London
- Cox, G., Lowe, P., Winter, M. (1985) Changing directions in agricultural policy: Corporatist arrangements in production and conservation policies Sociologia Ruralis vol. xxv, no. 2, pp 130-153
- Cox, G., Lowe, P., Winter, M. (1987) Farmers and the state: a crisis for corporatism The Political Quarterly vol. 58, no. 1, pp 73-81
- Crew, M.A. (1975) Theory of the firm, Longman: London
- Crow, G. (1989) The use of the concept 'strategy' in recent sociological literature Sociology vol. 23, p 1-24
- Cunningham, J. (1996) Green and pleasant landmark Guardian 30.10.96
- Cyert, R.M., March, J.G. (1963) A behavioural theory of the firm, Prentice-Hall: Englewood Cliffs, NJ
- Dahlman, C.J. (1980) The open field system and beyond, Cambridge University Press: Cambridge
- Daly, H. (1992) Steady state economics (second edition), Earthscan: London
- Dasgupta, P. (1982) Control of resources, Blackwell: London
- Davis, J.E. (1980) Capitalist agricultural development and the exploitation of the propertied laborer pp 133-153 in Buttel, F.H., Newby, H. (eds) The rural sociology of the advanced societies: Critical perspectives, Croom Helm: London

Davis, R.D. (1993) Agricultural utilization of sewage sludge p 17-25 in Jones, J.G. (ed) Agriculture and the environment, Ellis Horwood Ltd: Chichester

Demsetz, H. (1967) Toward a theory of property rights American Economic Association Papers and Proceedings May pp 253-257

Demsetz, H. (1988) Ownership, control and the firm, Basil Blackwell: Oxford

Dickens, P. (1992) Society and nature: Towards a green social theory, Harvester, Wheatsheaf: London

DoE (1992a) This Common Inheritance: Britains Environmental Strategy: Second Year Report, H.M.S.O: London

DoE. (1993a) Water charges: The quality framework, DOE: London

DoE. (1993b) Making markets work for the environment, H.M.S.O.: London

DoE (1994) Sustainable Development: The UK Strategy, H.M.S.O: London

DoE (1995a) Water conservation: Government action, DoE: London

DoE (1996a) Digest of Environmental statistics no. 18, H.M.S.O.: London

DoE (1996b) Water resources and supply: Agenda for action, Stationary Office: London

DoE and Maff (1995) Rural England: A nation committed to a living countryside, H.M.S.O: London

DoE, MAFF, Welsh Office (1991) Improving environmental quality: The Government's proposals for a new, independent Environment Agency, H.M.S.O: London

DoE, Welsh Office (1992b) Using water wisely: A consultation paper, DoE: London

DoE; MAFF; Welsh Office (1995a) Statutory Guidance: Under section 4 of the Environment Act 1995 with respect to objectives of the Environment Agency and its contribution towards achieving sustainable development, DoE: London

Downs, A. (1967) Inside bureaucracy, Little, Brown: Boston, Mass

Drysek, J. (1987) Rational ecology: Environment and political economy, Basil Blackwell: Oxford

Dubourg, W.R. (1993) Sustainable management of the water cycle in the UK, CSERGE Working Paper WM 93-02 University of East Anglia: Norwich

Dubourg, W.R. (1995) Pricing for sustainable water abstraction in England and Wales: A comparison of theory and practice, CSERGE Working paper WM 95-03 University of East Anglia: Norwich

East Anglian Daily Times 21.8.91 Lark Valley farmers banned from using river water

East Anglian Daily Times 23.7.91 Water rationing for some farmers

Eckersley, R. (1996) Markets, the state and environment: An overview pp 7-46 in Eckersley, R. (ed) Markets, the state and the environment: Towards integration, Macmillan Press: London

Eggertsson, T. (1990) Economic behaviour and institutions, Cambridge University Press: Cambridge

Ekinsmyth, C., Hallsworth, A., Leonard, S., Taylor, M. (1995) Stability and instability: The uncertainty of economic geography Area vol. 27, no. 4, pp 289-299

Emel, J., Peet, R. (1989) Resource management and natural hazards p 50-76 in Peet, R., Thrift, N. (eds) New models in geography vol. 2, Unwin Hyman Ltd: London

English Nature (1992) The Norfolk and Suffolk Brecks study, English Nature: Bury St. Edmunds

English Nature (1996) Impact of water abstraction on wetland SSSI's, English Nature: Peterborough

Environment Agency (1996a) The environment of England and Wales: A snapshot, Environment Agency: Bristol

Environment Agency (1996b) Upper Witham local environment agency plan. Consultation report, EA: Lincoln

Farmers Weekly (1996) Tape is a low cost alternative to surface irrigation systems 10.5.96

Fielding, N. (1993a) Qualitative interviewing pp 135 - 152 in Gilbert, N. (ed) (1993) Researching social life, Sage: London

Fielding, J. (1993b) Coding and managing data pp 218 - 239 in Gilbert, N. (ed) (1993) Researching social life, Sage: London

Fitzsimmons, M. (1986) The new industrial agriculture: The regional integration of speciality crop production Economic Geography vol. 62, no. 4, pp 334-353

Fitzsimmons, M. (1989) The matter of nature Antipode vol. 21, no. 2, p. 106-120

Flynn, A., Marsden, T. (1992) Food regulation in a period of agricultural retreat: The British experience Geoforum vol. 23, no. 1, pp 85-93

- Flynn, A., Marsden, T., Ward, N. (1994) Retailing, the food system and the regulatory state: Constructing the consumer interest pp 90-103 in Lowe, P., Marsden, T., Whatmore, S. (eds) Regulating Agriculture: Critical perspectives on rural change vol. 5, David Fulton: London
- Fowler, F. (1988) Survey research methods, (applied social research methods series, vol. 1) sage Publications: London
- Galbraith, J.K. (1967) The new industrial state, Hamish Hamilton: London
- Gerrard, S. (1995) Environmental risk management pp 296-316 in O'Riordan, T. (ed) Environmental science for environmental management, Longman: London
- Gibbons, D.C. (1986) Scarce water and institutional change, Resources for the Future: Washington D.C
- Giddens, A. (1979) Central problems in social theory: Action, structure and contradiction in social analysis, Macmillan: London
- Giddens, A. (1984) The constitution of society: An outline of the theory of structuration, Polity Press: Cambridge
- Gilbert, N. (ed) (1993) Researching social life, Sage: London
- Godwin, R.K., Shepard, W.B. (1979) Forcing squares, triangles and ellipses into a circular paradigm: The use of the commons dilemma in examining the allocation of common resources Western Political Quarterly vol.32, p.265-277
- Gower, B.S. (1992) What do we owe future generations pp 1-12 in Copper, D., Palmer, J. (eds) The environment in question: Ethics and global issues, Routledge: London
- Grabosky, P.N. (1996) Governing at a distance: Self regulating green markets pp 197-228 in Eckersley, R. (ed) Markets, the state and the environment: Towards integration, Macmillan: London
- Grant, W. (1983) The national farmers union: The classic case of incorporation pp 129-143 in Marsh, D. (ed) Pressure politics and interest groups in Britain, Junction Books Ltd.: London
- Hahn, R., Hester, G. (1989) Marketable permits: Lessons from theory and practice Ecology Law Quarterly vol. 16, no 2, p361-406
- Hahn, R.W., Noll, R.G. (1982) Designing a market for tradable emissions permits p 119-146 in Maget, W. (ed) Reform of environmental regulation, Ballinger: Cambridge, MA
- Hahn, R.W., Stavins, R.N. (1991) Incentive based environmental regulation, a new era for an old idea Ecology Law Quarterly vol. 18, no. 1, pp 1-42
- Hancher, L., Moran, M. (1989) Introduction: Regulation and deregulation European Journal of Political Research vol. 17, no. 2, pp 129-137
- Hanley, N. (1993) Controlling water pollution using market mechanisms: results from empirical studies, p360-383 in Turner, R.K. (ed) Sustainable environmental economics and management: Principals and practice, Belhaven Press: London

- Hardin, G. (1968) The tragedy of the commons Science vol.162, pp1243- 1248
- Hawkins, E. (1991) Changing technologies: Negotiating autonomy on Cheshire farms, Unpublished Phd thesis, South Bank Polytechnic, London
- Hawkins, E. (1994) Technological change and the regulation of agriculture pp 75-89 in Lowe, P., Marsden, T., Whatmore, S. (eds) Regulating agriculture: Critical perspectives on rural change vol. 5, David Fulton: London
- Herrington, P. (1973) Water demand study, Final report, University of Leicester
- Herrington, P. (1996) Climate change and the demand for water, H.M.S.O.: London
- Herrington, P. (1997) Pricing water properly p263-287 in O’Riordan, T. (ed) Ecotaxation, Earthscan: London
- Hindess, B. (1986) Actors and social relations pp 113-126 in Wadell, M.I., Turner, S.P. (eds) Sociological theory in transition, Allen and Unwin: Boston
- Hinton, L., Varvarigos, P. (1990) Observations on the economic performance of irrigation. A study of 23 farms in East Anglia, Department of Land Economy: Cambridge University
- Hirschleifer, J., DeHaven, J.C., Milliman, J.N. (1960) Water supply: Economics, technology and policy, Chicago University Press: Chicago
- Hodge, I. (1991) Incentive policies and the rural environment Journal of Rural Studies vol. 7, no. 4, pp 373-384
- Holmes, J. (1986) The organisational and locational structure of production subcontracting pp 80-106 in Scott, A.J., Stroper, M. (eds) Production, work, territory: The geographical anatomy of industrial capital, Allan and Unwin: London
- Howe, C.W., Schurmeier, D.R., Shaw, D.W. (1986) Innovative approaches to water allocation: The potential for water markets Water Resources Research vol. 22, no. 4, pp 439-445
- Jackson, T., Jacobs, M. (1991) Carbon taxes and the assumptions of environmental economics pp 49-67 in Barker, T. (ed) Green futures for economic growth, Cambridge Econometrics: Cambridge
- Jacobs, M. (1994) The limits to neo-classicalism: Towards an institutional environmental economics pp 67-92 in Redclift, M., Benton, T. (eds) Social theory and the global environment, Routledge: London
- Jacobs, M. (1996) Sustainability and the ‘market’: A typology of environmental economics pp 46-70 in Eckersley, R. (ed) Markets, the state and the environment: Towards integration, Macmillan: London
- Janicke, M. (1990) State failure: The impotence of politics in industrial society, Polity Press: Cambridge
- Johnson, P., McKay, S., Smith, S. (1990) The distributional consequences of environmental taxes, Institute of fiscal studies: London

- Kates, R.W. (1962) Hazard and choice perception in flood plain management Research paper no. 78 Dept. of Geography, University of Chicago
- Kates, R.W. (1985) Hazard assesment: Art, source and ideology p 251-264 in Kates, R.W., Hohenemser, C., Kasperson, J.X. (eds) Perilous progress: Managing the hazards of technology, Westview Press: Boulder, CL
- Kinnersley, D. (1994) Coming clean: The politics of water and the environment, Penguin: London
- Kirkman, M.A., Davies, H.V., Harkett, P., Storey, R.M.J. (1991) Research review: Processing, PMB: Oxford
- Krizner, I.M. (1991) Market process versus market equilibrium pp 53-66 in in Thompson, G., Frances, J., Levacic, R., Mitchell, J. (eds) Markets, hierarchies and networks, Sage: London
- Lash, S., Wynne, B. (1992) Introduction pp 1-9 in Beck, U. Risk Society: Towards a new modernity, Sage Publications: London
- Latour, B. (1987) Science in action, Open Universty Press: Milton Keynes
- Latour, B. (1986) The powers of associations pp 264-280 in Law, J. (ed) Power, action and belief: A new sociology of knowledge, Routledge: London
- Lester, A. (1949) Equilibrium of the firm American Economic Review, March
- Levacic, R. (1991) Markets and Government: An over view pp 35-48 in Thompson, G., Frances, J., Levacic, R., Mitchell, J. (eds) Markets, hierarchies and networks, Sage: London
- Leyshon, A. (1992) The transformation of the regulatory order: Regulating the global economy and environment Geoforum vol. 23, no.3, pp 249-269
- Lindblom, C.E. (1959) The science of muddling through Public Administrative Review vol. 19, no 2, pp 79-88
- Lingard, J., Gowing, J. (1995) The economic value of water Irrigation News no. 24, pp14-23
- Lofland, J. (1971) Analysing social settings: A guide to qualitative observation and analysis, Wadsworth: Belmont, C.A.
- Long, R.B. (1990) A tradeoff analysis of alternative water uses Water Resources Bulletin vol. 26, no. 1, pp 157-166
- Long, N. (1992) From paradigm lost to paradigm regained? A case for an actor orientated sociology of development pp 16-47 in Long, N., Long, A. (eds) Battlefields of Knowledge: The interlocking of theory and practice in social research and development, Routledge: London
- Long, N. (ed) (1989) Encounters at the Interface: A perspective on social discontinuities in rural development, Wageningse Sociologische Studies 27: Wageningen
- Lowe, P., Goyder, J. (1983) Environmental groups in politics, George Allen and Unwin: London

- Lowe, P., Marsden, T.K., Whatmore, S. (1994) Changing regulatory orders: The analysis of the economic governance of agriculture pp 1-30 in Lowe, P., Marsden, T.K., Whatmore, S. (eds) Regulating Agriculture, David Fulton: London
- MAFF (1991) Survey of irrigation of outdoor crops in 1990 in England and Wales, MAFF: London
- MAFF (1992) Making every drop count, MAFF, NRA, NFU, CLA.: London
- MAFF (1993) Survey of irrigation of outdoor crops in 1992 in England and Wales, MAFF: London
- MAFF (1995) Agriculture in the UK 1994, HMSO: London
- MAFF (1996) Good irrigation practice, MAFF: London
- Majone, G. (1989) Evidence, argument and persuasion in the policy process, Yale University Press: New Haven
- Marris, R. (1964) The economic theory of managerial capitalism, Macmillan: Basingstoke, Hants
- Marsden, T., Little, J. (1990) Introduction pp 1-19 in Marsden, T., Little, J. (eds) Political, social and economic perspectives on the International food system, Avebury: Aldershot
- Marsden, T., Murdoch, J., Lowe, P., Munton, R., Flynn, A. (1993) Constructing the countryside, U.C.L. Press: London
- Marsden, T., Murdoch, J., Williams, S. (1992) Regulating agricultures in deregulating economies: Emerging trends in the uneven development of agriculture Geoforum vol. 23, no. 3, pp 333-347
- Marsden, T., Whatmore, S., Munton, R. (1987) Uneven development and the restructuring process in British agriculture: A preliminary exploration Journal of Rural Studies, vol. 3, no.4, p 297-308
- Marsden, T., Wrigley, N. (1994) Retailing, the food system and the regulatory State pp 33-47 in Wrigley, N., Lowe, M.S. (eds) Retailing, consumption and capital: Towards the new retail geography, Longman: London
- Marsden, T.K., Arce, A. (1995) Constructing quality: Emerging food networks in the rural transition Environment and Planning A vol. 27, no. 8, pp 1261-1279
- Marsden, T.K., Munton, R., Ward, N. (1992) Incorporating social trajectories into uneven agrarian development: Farm businesses in upland and lowland England Sociologia Ruralis vol. xxxii, no.4, pp 408-430
- Marsden, T.K., Murdoch, J. (1990) Agriculture in retreat: Implications for the changing control and development of rural land. Working paper no. 9 ESRC Countryside Change Initiative, Newcastle
- Marsh, D. (ed) (1986) Pressure politics in interest groups in Britain, Junction Books: London
- Marshall, A. (1961) The principles of economics (Eighth edition), Macmillan: Basingstoke, Hants.

- Mason, J. (1994) Linking qualitative and quantitative data analysis pp 89-111 in Bryman, A., Burgess, R.G. (eds) (1994) Analysing qualitative data, Routledge: London
- McKay, B., Acheson, J.A. (1988) The question of the commons, University of Arizona Press: Tuscon AZ
- McGuire, J.W. (1964) Theories of business behaviour, Prentice-Hall: Eaglewood Cliffs
- Mishler, E.G. (1986) Research interviewing: Context and Narrative, Harvard University Press: Cambs. M.A.
- Mitchell, B. (1990) Integrated water management, Belhaven Press: New York
- Morris, J. (1993) The economics of irrigation for potatoes in Britain pp14-23 in Bailey, R. (ed) Irrigating Potatoes, Cranfield Press: UK Irrigation Association
- Moser, C.A., Kalton, G. (eds) (1971) Survey methods in social investigation, Heinemann Educational Books Ltd: London
- Munton, R. (1992) The uneven development of capitalist agriculture pp 25-48 in Hoggart, K. (ed) Agricultural change, environment and economy, Mansell: London
- Murdoch, J., Ward, N., Lowe, P. (1992) Rural sustainable development: A socio-political perspective on the role of agriculture, Paper presented at the Circle for Rural European Studies conference, Crete
- Naish, C.D. (1994) Water resources development for agriculture and the environmental implications pp 53-69 in Marshall, B.J., Miller, F.A. (eds) Water services and agriculture: Key issues and strategic options, CAS: Reading
- Nettl, J.P. (1957) A note on entrepreneurial behaviour Review of economic studies, vol. 24, pt. 2, pp 87-94
- Newbery, D.M. (1990) Acid rain Economic policy: A European forum October, pp 298-346
- Newson, M. (1991) Catchment control and planning Land Use Policy vol.8, no.1, p 9-15
- Newson, M. (1993) Land, water and development: River basin systems and their sustainable management, Routledge: London
- NFU (1994) The NFU-Retailer ICM protocol for fresh market potatoes, NFU: London
- NFU (1996) Evidence presented to the House of Commons Environment Committee on water conservation and supply (WCS 105) Stationary Office: London
- NIAB (1995) Potato variety handbook, National Institute Agricultural Botany: Cambridge, UK
- Nix, J. (1994) Farm management pocketbook Wye college: University of London

- Norgaard, R.B. (1994) Development betrayed, Routledge: London
- Norgaard, R.B.(1985) Environmental economics: An evolutionary critique and plea for pluralism Journal of environmental economics and management vol.12, no. 4
- NRA (1990) NRA takes action on disappearing rivers Press release 27.2.90
- NRA (1992a) Policy and practice for the protection of ground water, H.M.S.O: London
- NRA (1992b) Water resources development strategy: A discussion document, NRA: Bristol
- NRA (1992c) Managing drought and water resources: Key statements approved by the Board of the NRA, NRA: Bristol
- NRA (1993a) Anglian Water Resources Strategy: Consultation report, NRA: Peterborough
- NRA (1993b) Low flows and water resources: Facts on the top 40 low flow rivers in England and Wales, NRA: Bristol
- NRA (1993c) Regional water sources strategy: Severn Trent region, NRA: Solihull
- NRA (1994a) Water Resources in Anglia: A sustainable strategy for secure water supplies and a better water environment, NRA: Peterborough
- NRA (1994b) Water: Nature's precious resource: An environmentally sustainable water resources development strategy for England and Wales H.M.S.O.:London
- NRA (1994c) Sustaining our resources: The way forward, NRA: Worthing
- NRA (1994d) Future water resources in the Thames region, NRA: Reading
- NRA (1995a) Bathing water quality in England and Wales 1995, Water Quality Series, no. 19
NRA: Bristol
- NRA (1995b) Water pollution incidents in England and Wales in 1994, Water Quality Series, no. 25, NRA: Bristol
- NRA (1995c) Tomorrows water: Water resources development strategy, NRA: Exeter
- NRA (1995d) Lower Witham catchment management plan. Consultation report, NRA: Lincoln
- NRA (1995e) Saving water: The NRA's approach to water conservation and demand management: A consultation report by the NRA, NRA: Bristol
- NRA (1995f) Annual report and accounts 1994-95, NRA: Bristol

- NRA (1996) Leakage levels update 1994-95 The demand management bulletin, no. 15
- O’Riordan, T. (1976) Environmentalism, Pion Limited: London
- O’Riordan, T., Turner, R.K. (1983) An annotated reader in environmental planning and management, Pergamon Press: Oxford
- O.E.C.D. (1989) Water resource development: Integrated policies, OECD: Paris
- OFWAT (1992) The cost of quality: A strategic assesment of the prospects for future water bills
OFWAT: Birmingham
- OFWAT (1993a) Paying for quality: The political perspective OFWAT: Birmingham
- OFWAT (1993b) Paying for growth. A consultation paper on the framework for reflecting the costs of providing for growth in charges, OFWAT: Birmingham
- OFWAT (1994a) Future levels of demand and supply for water OFWAT Occasional Paper 1
- Ogus, A.I. (1994) Regulation: Legal form and economic theory, Clarendon Press: Oxford
- P.O.S.T. (1993) Dealing with drought: Environmental and technical aspects of water shortages,
P.O.S.T.: London
- Papondreau, A.G. (1952) Some basic problems of the theory of the firm in Haley, B. (ed) A survey of contemporary economics, Irwin Press: Homewood, IL
- Park, C.P. (1987) Acid rain: Rhetoric and reality, Methuen: London
- Parker, D.J., Penning-Rowsell, E.C. (1980) Water planning in Britain, George Allen and Unwin: London
- Parry, M., Duncan, R. (eds) (1995) The economic implications of climate change in G.B., Earthscan: London
- Pearce, D., Markandya, A., Barbier, E.B. (1989) Blueprint for a green economy, Earthscan: London
- Pearson, M., Smith, S., (1990) Taxation and environmental policy: Some initial evidence, Institute for Fiscal Studies: London
- Perlman, M. (1976) The economic theory of bureaucracy pp 70-79 in Tullock, G. (ed) The vote motive, Institutue of Economic Affairs: London
- PMB (1995) Annual report and accounts 1995, PMB: Oxford

- PMB (1996) Potato statistics in GB 1991-1995, PMB: Oxford
- Pollit, M. (1991) Growers plea on irrigation East Anglain Daily Press, 8.4.91
- Porter, E. (1978) Water management in England and Wales, Cambridge University Press: London
- Porter, M. (1994) 'Second hand ethnography': Some problems in analysing a feminist project pp 47-67 in Bryman, A., Burgess, R.G. (eds) (1994) Analysing qualitative data, Routledge: London
- Postel, S. (1992) The last oasis: Facing water scarcity, Earthscan: London
- R.S.P.B. (1988) The reform of the CAP: New opportunities for wildlife and the environment, R.S.P.B.: Sandy, Beds
- R.S.P.B. (1990) Agriculture and the Environment: Towards integration, R.S.P.B.: Sandy, Beds
- R.S.P.B (1996) High and dry: The impact on wildlife of taking too much water from our environment, RSPB: Sandy, Beds
- Redclift, M. (1988) Economic models and environmental values: A discourse on theory pp 51-67 in Turner, R.K. (ed) Sustainable Environmental Management: Principles and Practice, Belhaven Press: London
- Redclift, M.R. (1992) A framework for improving environmental management: Beyond the market mechanism World Development vol. 20, no.2, pp 255-259
- Rees, J.A. (1973) A review of the evidence on the effects of prices on the demand for water services Report to the DoE
- Rees, J.A. (1976) Rethinking our approach to water supply provision Geography vol.61, no. 4, pp 232-245
- Rees, J.A. (1978) The management of urban domestic water services: Studies in Australia and in England and Wales Unpublished phd thesis, L.S.E.: London
- Rees, J.A. (1990) Natural resources: Allocation, economics and policy (second edition), Routledge: London
- Rees, J.A. (1992) Markets: The panacea for environmental regulation? Geoforum vol. 23, no. 2, pp 383-395
- Rees, J.A. (1997) Towards implementation realities pp 287-304 in O'Riordan, T. (ed) Ecotaxation, Earthscan: London
- Rees, J.A., Williams, S., Atkins, J.P., Hammond, C., Trotter, S. (1993) The economics of water resource management, Bristol: NRA
- Rees, J.A., Williams, S.E. (1993) Water for life: Strategies for sustainable water resource management C.P.R.E: London

- Renn, O. (1992) Concepts of risk: A classification pp 53-83 in Krinsky, S., Golding, D. (eds) Social theories of risk, Praeger Publishing: Westport, CT
- Richardson, J.J., Jordan, A.G., Kimber, R.H. (1978) Lobbying, administrative reform and policy style. The case of land drainage Political Studies vol. 26, no. 1, pp 47-64
- Roberts, R.S., Emel, J. (1992) Uneven development and the tragedy of the commons: competing images for nature-society analysis Economic Geography vol. 68, pp 249-271
- Royal Society (1992) Risk analysis: perception and management, The Royal Society: London
- Sagoff, M. (1988) The economy of the earth, Cambridge University Press: Cambridge
- Schmitter, P.C. (1981) Interest intermediation and regime governability in contemporary Western Europe and North America pp 285-327 in Berger, S.D. (ed) Organizing interests in Western Europe, Cambridge University Press: Cambridge
- Schnaiberg, A. (1980) The environment: From surplus to scarcity, Oxford University Press: New York
- Schumpeter, J.A. (1934) The theory of economic development, Harvard University Press: Cambridge, Mass
- Scitovsky, T. (1943) A note on profit maximisation and its implications Review of economic studies vol. 11, no. 1, pp 57-60
- Segerson, K. (1992) The policy response to risk and risk perceptions pp 101-130 in Bromley, D.W., Segerson, K. (eds) The social response to environmental risk: Policy formulation in an age of uncertainty, Kluwer Academic Publications: Boston
- Simmons, R.J., Baden, J. (1984) The theory of the NRE pp 25-33 in CEI (ed) Readings in Free Market Environmentalism, The Competitive Enterprise Institute: Washington D.C.
- Simon, H.A. (1947) Administrative behaviour, Macmillan: New York
- Simon, H.A. (1955) A behavioural model of rational choice Quarterly Journal of Economics, vol. 69, no.2, p 99-118
- Simon, H.A. (1957) Models of man: Social and Rational, Wiley: New York
- Smith, N. (1984) Uneven development: Nature, capital and the production of space, Basil Blackwell: London
- Smyth, P. (1995) Group initiatives in medium scale and strategic development Irrigation News no. 24, pp 37-45
- Stanworth, J., Curran, J. (1973) Management motivation in the smaller business, Gower Press: Epping
- Storey, D.J. (1982) Entrepreneurship and the new firm, Croom Helm: London
- Strauss, A.L. (1987) Qualitative analysis for social scientists, Cambridge University Press: Cambridge and New York

- Tate, D.M. (1989) Water demand management in Canada: a state of the art review, Social science series no 23. Inland waters directorate, water planning management branch, Ottawa Canada
- Tietenberg, T.H. (1991) Economic instruments for environmental protection pp 86-111 in Helm, D. (ed) Economic policy towards the environment, Blackwell: Oxford
- Vogel, D. (1986) National styles of regulation: Environmental policy in Britain and the United States of America, Cornell University Press: Ithaca
- Ward, N. (1994a) Pesticide pollution in the post-productivist countryside. Paper presented at the IBG conference, Nottingham, Jan. 1994
- Ward, N. (1994b) Farming on the treadmill: Agricultural change and pesticide pollution unpublished Phd thesis, University College London
- Ward, N., Munton, R. (1992) Conceptualising agriculture-environment relations: Combining political economy and socio-cultural approaches to pesticide pollution, Sociologia Ruralis vol. 32, pp 127-145
- Watts, M. (1983) Hazards and crisis: A political economy of drought and famine in Northern Nigeria Antipode vol. 15, no. 1, pp 24-34
- Watts, M. (1989) The agrarian crisis in Africa: Debating the crisis Progress in Human Geography vol. 13, no. 1, pp 1-41
- WCA (1996) Evidence presented to the House of Commons Environment Committee on water conservation and supply (WCS 58) Stationary Office: London
- Weale, A. (1992) The new politics of pollution, Manchester University Press: Manchester
- Weatherhead, E.K., Price, A.J., Morris, J., Burton, M. (1994) Demand for irrigation water, H.M.S.O.:London
- Whatmore, S., Boucher, S. (1993) Bargaining with nature: The discourse and practice of 'environmental planning gain' Transactions of the Institute of British Geographers NS 18 p166-178
- Wheeler, B.B., Shaw, S.C. (1992) Biological indicators of the dehydration and changes to East Anglian Fens, past and present English Nature Research Report, no. 20: Peterborough
- White, G.F. (1945) Human adjustments to floods, Research paper no. 29, Chicago II: University of Chicago, Department of Geography
- White, G.F. (1974) Natural hazards: Local, national, global, Oxford University Press: New York
- Williamson, O.E. (1964) The economics of discretionary behaviour: Management objectives in a theory of the firm, Prentice-Hall: Englewood Cliffs, NJ
- Winpenny, J. (1994) Managing water as an economic resource, Routledge: London
- Wise, C.J.C. (1994) The NFU-Retailer integrated crop management protocols, NFU: London
- WSA (1995) Water facts, Water Services Association: Sheffield

WSA (1996) Evidence presented to the House of Commons Environment Committee on water conservation and supply (WCS 81) Stationary Office: London

Yandle, B. (1989) The political limits of environmental regulation: Tracking the unicorn, Greenwood Press: Westport, C.T.

APPENDIX A
FOCUSED INTERVIEW SCHEDULE - PHASE ONE.

Topic headings and introductory questions.

1. Details of on-farm irrigation use.

What quantity of water are you licensed to abstract?

What quantity of water do you actually abstract?

What types of irrigators do you use? (number, cost, date, grant)

Do you have any form of winter water storage? (number, cost, date, grant)

2. Details of the Irrigated crops.

Turning now to the farm itself, what is the total utilised area of the farm? (owned/rented)

Can you give me some idea of the predominant soil type on the farm?

What rotation do you follow?

What potato varieties do you grow?

Can you outline the acreage of each?

Can you outline which crops are irrigated, and the yield?

3. Details of the farmer.

Are you the principal decision maker on the farm?

When did you take on this farm?

When you are no longer involved farming here, do you expect any of your family to succeed you actively farming this land?

How many people are employed on the farm full/part time?

4. Change in the structure of the farm.

Can you outline the major changes which have occurred on the farm since 1992?

What have been the key changes in relation to the management of irrigation water over this period?

5. Irrigation decision making.

Which are the priority water crops on the farm?

Can you outline the criteria which you use to decide which crops or varieties receive water?

Do you receive any advice from off the farm on when to apply the water?

6. Water history

What have been the key water events on the farm?

How did you cope with the drought of 1989-92?

Has your demand for water changed since the drought?

7. Marketing links.

How do you market the irrigated crops?

What are the key criteria set down by the off farm firms?

How do you ensure through farm management that these criteria are actually met?

How important is water application in ensuring this?

8. Marketing futures.

Looking to the future, and the possible winding down of the PMB how will you then market your potato crop?

9. NRA links and negotiation

Have you applied to the NRA to have your abstraction licence changed?

During a drought period do you keep in contact with the NRA personnel to gauge the possibility of an abstraction ban being imposed?

If an abstraction ban is imposed, and you feel that the conditions are unfair, have you negotiated with the NRA to persuade them to change?

Did you negotiate as a collective group of farmers or individually?

10. Understanding of water issues.

How important is water as an input for use on the farm?

Does access to water affect the production or crop choices on the farm?

How is water different to other production inputs?

How important is access to water for the development of the farm?

Do you think that your use of water has any implications for the environment?

If a river passes through your farm, should you automatically be allowed to use that water?

11. Scenarios.

In a hypothetical situation how would you react if:

- (i) your water licence was cut by half permanently?
- (ii) the cost of the abstracted water you used was increased by 25%?
- (iii) a new company up stream of your farm decided to apply for a large licence to abstract water from the same river, and this abstraction could potentially reduce the flow level of the river and therefore cause problems for your abstraction?
- (iv) a rare water plant was found in a pool down stream from your abstraction point, and the NRA wanting to protect it, decided that you could only abstract water in the winter into a reservoir?

APPENDIX B

**METHOD FOR THE CALCULATION OF THE VALUE IN USE OF IRRIGATION
WATER**

VALUE IN USE: GROSS MARGIN ANALYSIS

Gross margin analysis allows estimates to be made of the value of the productivity gains generated by water use and the productivity losses from restricted water availability. The valuation procedure involves several steps:

1. Under current irrigation and land allocation practices, estimates are made of the gross margins (total output minus variable input costs) achieved by the farm enterprises.
2. It is then assumed that no irrigation water is available and that farmers change their crop mix to that which yields the highest net returns under dry farming. This produces a new, without irrigation, set of gross margin estimates.
3. By comparing the difference between the gross margins calculated under (1) and (2) above, an estimate can be made of the short run value in use of the irrigation water. Such short run values are important since they will be critical to the farmers' response to any unit water price rise, once they have undertaken investment in water storage and irrigation equipment.
4. To obtain longer term value in use measures and to estimate the demand for new abstraction authorisations it is necessary to take account of the costs incurred in water storage and irrigation. Thus, for irrigation to be financially viable, total gross margins with irrigation less the discounted annual irrigation costs (capital and operating) must be greater than the margins achieved without irrigation (those calculated under step 2).

From the farm survey data on the current land allocations, irrigated acreage, yields, and water application were obtained for the 1993-94 season. Nevertheless it was not feasible to obtain the highly detailed information on achieved crop sale prices and the general variable costs associated with the production of individual crops or livestock enterprises. Therefore, gross margin data for the first step in the valuation procedure was obtained from secondary sources. The main source was the Farm Business Survey of the Eastern Counties of 1993 (Cambridge 1995), and this was supplemented by data from Nix (1994). Use of the Cambridge survey as the primary information source necessitated disaggregation of the surveyed farms into two groups based on the soil type, namely Breckland farms (for farms in the Thet-Little Ouse and Lark catchments) and upland farms under 400 hectares (for farms in the Bain-Witham catchment). The gross margin values for the potato crop were varied in line with the significant price variations associated with the different market outlets. Hence, in accordance with Morris (1993) values varied from £50/t for general ware potatoes; £80/t for processing potatoes and £150/t for pre-pack standard potatoes.

Information for step two of the valuation procedure was obtained from the farm interviews. It was assumed that the shift to dry land farming, would lead to the reallocation of previously irrigated land into winter wheat production.

EXPENDITURE ON WATER STORAGE AND IRRIGATION EQUIPMENT.

To undertake the cost analysis a number of simplifying assumptions are necessary. First, since investment in irrigation equipment and storage took place in different time periods, it is necessary to convert the expenditure to a single time value, to ensure that the figures are comparable. In effect, the investment was treated as if it had taken place in 1992, immediately prior to the harvest season in which the farm survey occurred. All the irrigation investment costs were converted to 1992 values using the national retail price index (RPI) as published in Economic Trends (CSO Annual). Second, a set of assumptions were made, associated with the notion that capital goods represent stock variables whereas the services they render are flow variables. In consequence, it is necessary to convert the stock valuations into a stream of annual expenditures. The cost of irrigation equipment investment comprises two elements: depreciation and the opportunity cost of funds employed. Using standard farm management procedures, depreciation was calculated on a linear basis and related to years of expected life of the relevant facility. Reservoirs were assumed to have a life of 30 years with an annual depreciation rate of $1/30$ implied; other source works, pumps and power units, portable field applicators and miscellaneous equipment were assumed to have a life of 15 years with an implied depreciation rate of $1/15$ per annum. The opportunity cost of capital was calculated at 7%, in line with current public sector guidelines. Investments made prior to 1960 were assumed to have been fully depreciated and have a zero opportunity cost of funds employed. The opportunity costs of all funds employed and the physical depreciation of the actual facilities are associated with the initial outlay and maintenance of the capital stock. It is also necessary to consider the recurrent or operating costs. In the case of storage facilities, operating costs are assumed to be negligible and a zero cost imputed. The operating costs for irrigation equipment, in contrast are likely to be quite significant, including the labour, fuel and actual water costs (Hinton and Varrarigos 1990; Weatherhead *et al* 1994). However, the estimates presented here exclude these costs as attempts to elicit this information directly from the farmers proves problematic.