UNIVERSITY OF
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Department of Land Economy

Prospects and opportunities for rural land management on The Crown Estate

A report for The Crown Estate

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"Well before 2050, the world will need farming systems capable of feeding 8-11 billion people within a resource-light, low carbon economy."
'Food Matters: Towards a Strategy for the 21st Century'
The Strategy Unit, Cabinet Office, July, 2008, p.ix

"We believe that our stewardship role on our estates should leave a legacy for future generations and be an example to others."
The Crown Estate website

Acknowledgements
The authors are grateful to The Crown Estate for supporting this project. However, the views expressed are those of the authors and The Crown Estate bears no responsibility for the contents.

1. Introduction and approach to the study

The objective of the project

The objective of the project is to review prospects for the rural land on The Crown Estate across Great Britain in terms of the likely constraints and opportunities in general terms over a 20 year time horizon and to draw out implications for the options and opportunities facing the management of The Crown Estate at the present time.

This report has been prepared at a time of considerable uncertainty for the future of rural land. The long terms trends of declining food prices and liberalisation of agricultural policy have been challenged by the more recent commodity price increases and the apparent failure of the Doha Round of world trade negotiations. Whether or not the higher prices and reassessment of policy approaches represents a sea change or short term spike remains uncertain. We have seen a considerable decline from the highest prices seen in 2008 and as the economic recession deepens, oil prices have also fallen to levels last seen in 2005. At the same time, the threat of severe and potentially catastrophic climate change means that we are almost certainly moving towards a policy environment that will demand radical reductions in Greenhouse Gas (GHG) emissions and oblige adaptation to altered climatic conditions. A number of studies are due to report in the coming months on climate change predictions, land use and potential approaches to GHG emission reductions in farming and these may shed more light on the probable directions of change. But concerns as to the longer term threats associated with global population pressures, economic growth and climate change are undiminished (as illustrated by the recent speech by Beddington[1]). However, research cannot resolve the issues and in these circumstances, we may expect the flow of research and evaluation to be a constant state of affairs. We cannot know what the future holds, even when we appear to be set on a particular longer term trend.

Our approach has therefore been to review the information available at the present time and the assessments being reached across a range of relevant areas. We have taken a broad view of the prospects for The Crown Estate. Our focus has been on general trends and implications, rather than attempting to offer a detailed programme that The Crown Estate should adopt. Our aim is thus to raise awareness and the promote discussion rather than to prescribe specific solutions. This is not a study of The Crown Estate. We are conscious that there have been specific studies on specific topics on The Crown Estate, but we have not attempted to assess or develop specific proposals from them.

The report is presented in eight sections. After this introduction, we outline very briefly some key aspects of The Crown Estate and its objectives, with a little more detail on the Rural Estate. We then discuss the drivers that will be influential in determining the conditions facing The Crown Estate in 20 years' time, concentrating

[1] Beddington, John (2009) Speech at the Sustainable Development UK conference, London, 19 March, 2009

on commodity prices, agricultural policy, climate change and forestry. As an approach to focussing and organising discussion around the future prospects, we develop four scenarios that aim to represent critical uncertainties and consider how they would affect the operation and performance of the rural sector generally and The Crown Estate more particularly. We then explore a range of issues facing individual businesses and develop some illustrative budgets for some farm types that are representative of the farm businesses on The Crown Estate based on what seem plausible levels of returns and costs. These illustrate the impact of alternative price assumptions and the differences in the ways in which they are likely to impact on different farm types. Finally we explore what appear to be the important opportunities and threats for The Crown Estate as a whole and for the businesses operating on it. Then we draw some conclusions and make recommendations.

2. The Crown Estate

The origins of The Crown Estate go back to the reign of King Edward the Confessor and the Sovereign received its rents, profits and expenses until 1760. At that time, the annual surplus after deducting management costs was surrendered to Parliament to help meet the costs of civil government. In return, the Sovereign receives the civil list and the Government meets other official expenditure incurred in support of the Sovereign.

The Crown Estate is divided into four separate elements: the Urban, Marine, Rural and Windsor Estates (The Crown Estate, 2008). The Urban Estate is comprised of 600 commercial properties in London and elsewhere as well as 2,600 residential properties. The Marine Estate includes 55% of the UK's foreshore, the beds of tidal rivers and estuaries and almost all the seabed out to the 12 nautical mile territorial limit. The Rural Estate holds 119,000 hectares of agricultural land, forests, residential and commercial property in England Scotland and Wales. There are also 34 active mineral lettings. The Windsor Estate covers around 6,300 hectares, including Windsor Great Park, Home Park and various properties. The Crown Estate has a duty to maintain the character of the Great Park as a Royal Park and Forest.

The turnover and values of The Crown Estates are indicated in Table 2.1

Table 2.1: Turnover and values of The Crown Estate properties

	Turnover	Property value
Urban Estate	£194.4m	£5,381m
Marine Estate	£41.9m	£370m
Rural Estate	£22.5m	£903m
Windsor Estate	£5.8m	£173m

Source: The Crown Estate, *Annual Report,* 2008

2.1 Objectives of The Crown Estate

The Crown Estate is managed by The Crown Estate Commissioners under powers granted by The Crown Estate Act 1961. They have a general duty, while maintaining The Crown Estate as an estate in land (Section **1** (3)) "*to maintain and enhance its value and the return from it, but with due regard to the requirements of good management*".

The Crown Estate makes a 'Corporate Responsibility Statement' that commits it to sustainable development "underpinned by our three core values – commercialism, integrity and stewardship". Notwithstanding the challenges faced, their "commitment to corporate responsibility remains unabated and we will continue to seek ways to increase its profile within the business and to find innovative ways of doing business that are more efficient and sustainable".

With regard to the environment, The Crown Estate states:

> "We believe that our stewardship role on our estates should leave a legacy for future generations and be an example to others. We aim to operate as a lean and enterprising organisation that uses resources efficiently; minimises emissions to land, air and water; curbs the production of waste and increases its recycling; and conserves and enhances those parts of The Crown Estate rich in biodiversity and architectural and historical value."[2]

With regard to rural stewardship, protecting the long-term value, The Crown Estate states:

> "Working in partnership with our managing agents, our customers and tenants, we aim to improve the social and environmental standards of The Crown Estates and minimise the impact of our activities."[3]

Given this approach, our discussion aims to take full account of the social and public aspects and implications of land use on The Crown Estate as well as the private and financial aspects.

2.2 The Rural Estate

The Rural Estate includes property in England, Wales and Scotland and comprises some 119,000 ha of land made up of 780 agricultural tenancies and 750 residential properties. This implies an average agricultural holding size of around 150ha. The rural estate generates £22.4 million in revenues (Table 2.2) and the agricultural land is valued at £6,255 per hectare (Table 2.3). The Crown Estate also includes a significant area of forestry, part let and part managed in hand. Within the Estate there is the last remaining common field estate at Laxton in Nottinghamshire where the medieval 'open field' system of farming has been retained.

[2] http://www.thecrownestate.co.uk/cr/cr8environment.htm
[3] http://www.thecrownestate.co.uk/rural_stewardship

Table 2.2: Revenue account for the Rural Estate, 2007-08

	£'000
Turnover	
Rent and royalties	21,964
Premiums on leases	20
Sale of produce	315
Other	157
Total	**22,456**
Operating costs	
Management fees and costs	3,333
Repair and maintenance	1,972
Other expenditure	489
Total	**5,794**
Gross surplus	**16,662**

Source: The Crown Estate, Annual Report 2008

Agricultural and use and land grade are illustrated in Figures 2.1. The predominant land use is for arable agriculture and most of the land is in grades II and III, although there is a significant area of Grade I agricultural land.

Figure 2.1: Types of Land Use and Agricultural Grades in the Rural Estate

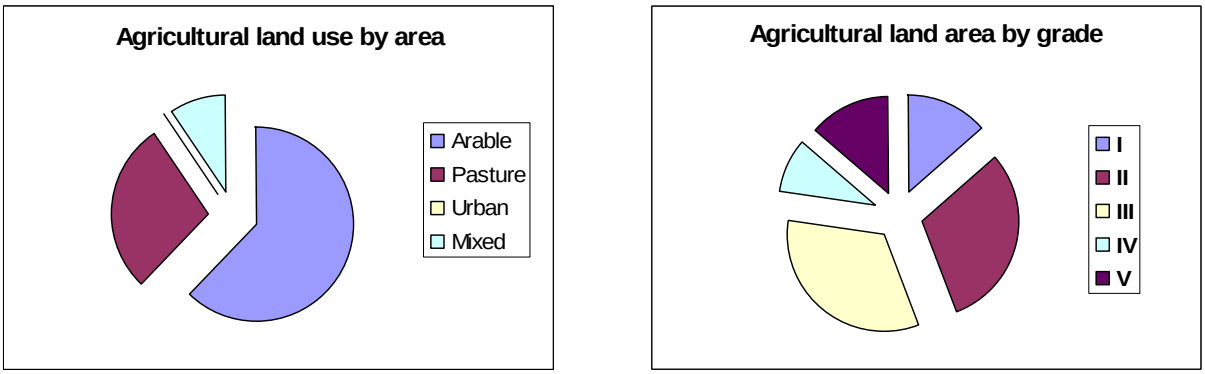


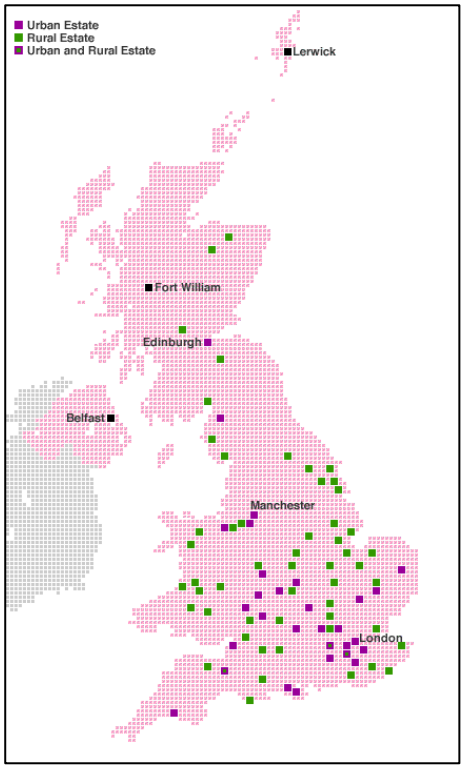
Table 2.3: Land values on the Rural Estate

	value £ per ha
Arable	6,646
Pasture	3,975
Urban	699,293
Mixed	10,582
Total	6,255

Valuation as at: 31 March 2007

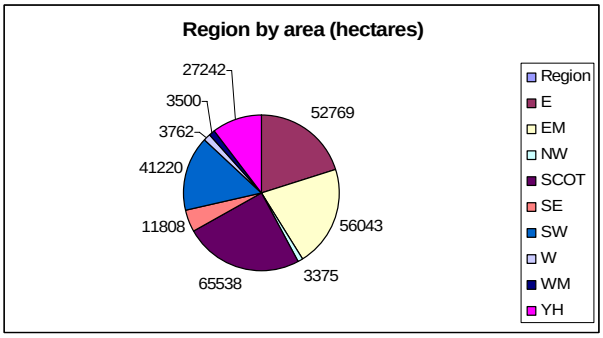
The Rural Estate is spread quite widely around the country, located primarily in England, but also with land in Scotland and Wales. Within England, the largest areas of land are in the East, East Midlands and South West regions. The locations of the different estates are illustrated in Figure 2.2. The majority of the agricultural land in the Rural Estate is located in England especially in the lowland areas, although there are also upland areas and land in Scotland. Nearly 11,000 ha are in forestry, just over 60% of which is in hand. This is the primary focus of our attention.

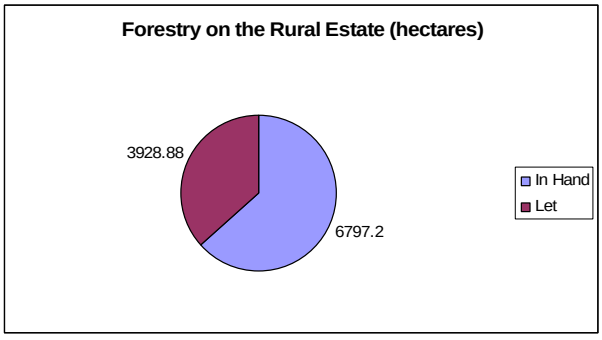
Figure 2.2: Locations of the Estates



Source: http://www.thecrownestate.co.uk/70_interactive_maps_urban_rural

Figure 2.3: Regional Breakdown and Forestry on the Rural Estates





The current forest estate[4]

The forestry portfolio in England and Scotland extends to almost 14,000 hectares, of which 9,952ha are managed in hand and 4,032ha are leased to the Forestry Commission.

A third of the in-hand forests comprise the Windsor Forestry Estate which, by reason of its connection with Windsor Castle, has to meet very high standards of appearance and maintenance, as well as meeting relatively high pressures from visitors, both residents and international tourists. The other major elements in the portfolio are: Glenlivet (with Auchindon) – 3,800ha in northern Scotland; Dunster – 1,025ha on the edge of Exmoor; and Applegirth – 672ha in south-west Scotland. Six other units range from 100-250ha, situated from Somerset and Kent to the north of Scotland. These minor units may seem small by comparison with the Glenlivet and Windsor estates, yet they are large by comparison with much private woodland ownership in this country.

Many of the minor woodland estates have been termed as essentially farm woodlands. Many provide important shelter functions for farming enterprises. Many constitute the main elements in the provision of shooting opportunities, an important commercial enterprise in some cases. Most are significant elements in the landscape and some offer useful recreational access. Most would be described as comprised of fragmented, small blocks, often lacking good access for management purposes and some have been subject to minimal management activity in recent years.

Most of the woodlands are managed within the terms of an appropriate FC grant scheme. On the major estates, including Windsor, commercial timber production is a key objective, but in all cases multiple goals include landscape enhancement, wildlife conservation and provision for recreation and tourism. Essentially, the overall aim is to contribute value annually to the total estate, through a commercial approach to forestry, while demonstrating management good practice and adding to the integrity of the agricultural estate.

Following the 2005 review, the recommendation was for 'the woodland estate to contribute to the Corporate Objectives through:

- Being a public demonstration of The Crown Estate's commitment to good stewardship and quality of performance, particularly through enhancing public access.
- Developing the woodland estate's contribution to the environment, by addressing landscape and ecological issues and adding to the integrity of the agricultural estate.
- Applying best commercial management practice to secure the optimum return from timber production and other forest based activities.' [5]

[4] This summary of the forest estate and current strategy and performance is based largely on the Final Report of a Review of Forestry Strategy prepared by Bruton Knowles in 2005 and discussions with Mr Andrew Wells, Director of Countryside and Forestry Services, to whom grateful thanks are extended. Responsibility for errors rests with the authors of this current report.

[5] Op. cit. p35.

The rural estate as a whole seeks to follow principles of integrated estate management and a potentially interesting study is underway with the Macaulay Institute on Glenlivet as an integrated estate, including energy provision and consumption.

Over six years, from 1998 to 2004, the forestry portfolio revenue performance varied from a peak surplus of £193,000 in 2000/01 to a deficit of £112,971 in 2003/04. The last two or three years will almost certainly have seen improved performance in the wake of higher prices for standing timber. The fluctuating revenue from timber sales reflects both fluctuations in the volume of timber available for sale and in the unit prices obtainable in the market. The estate has been able to take a long-term view and has not felled timber prematurely purely to boost revenue in a year of low prices.

The forest estate has a reputation as extremely well managed, and has won many awards for the quality of its management of different parts of the forests over the past fifteen years.

What is necessary to maintain its position over coming decades as a forest estate at the leading edge of sustainable land management practice? What are the likely constants (if any) and what changing circumstances are likely to pose significant challenges and opportunities for the estate? These issues are discussed below in Section 3.5.

3. Drivers of change on The Crown Estate

Prospects for rural land use face particular uncertainties. We have seen dramatic increases in the levels of commodity prices over the past couple of years followed by some declines from the peak levels. These higher prices may potentially herald a major break from the experience of a general decline in price levels that has been the general experience of much of the past fifty years. There are major challenges to the global economy associated with the 'credit crunch' and the economic recession that have the potential to affect rates of economic growth over a substantial period of time. Oil and other commodity prices have reached historically very high levels, but then fallen back, but with the potential for a return to higher price increases in the longer term. The political recognition of the reality of climate change and its potentially stark implications may lead to radical changes in policies in order to mitigate the impacts and adapt to its consequences. Much will depend on the level of political pressure and the degree of conflict perceived between addressing the problems of climate change and economic recession. The outcomes of these uncertainties will have significant implications for land uses across the world but are at present clouded in considerable uncertainty. The progress made at the international meeting in Copenhagen in December 2009 will provide a good indication of the level of response that may be expected.

As a result, the issues of commodity prices, economic prospects, climate change and land use are currently the subject of a considerable volume of study and assessment. Much has been written in recent months and a variety of studies are due to report in the coming months. A major Foresight study is currently underway that is looking at land use futures over the next 50 years. It is due to report in January 2010[6]. However such studies will not substantially resolve the major uncertainties that are faced.

3.1 A general summary of drivers

While the future is uncertain, is possible to outline the factors that we anticipate will influence conditions for The Crown Estate over the coming twenty years or so. Various ways have been suggested for identifying the ranges of drivers that may influence development in the future. One simple approach uses the acronym STEEP to represent: Society, Technology, Economy, Environment and Politics. Adopting these categories, the major drivers likely to be of significance are summarised in Tables 3.1 to 3.5.

[6] http://www.foresight.gov.uk/OurWork/ActiveProjects/LandUse/LandUse.asp

Table 3.1 Environmental factors

Climate Change	Effects of climate change over 20 years and anticipated changes in longer term: climate, temperature, rainfall uncertainty. Adaptation to changes in crop and livestock production patterns in Great Britain. Mitigation options likely to have impact. Indirect effects: destabilised world commodity prices; international migration, conflicts over resources
Water quantities	Flooding and drought
Water quality issues	Water Framework Directive
Animal Health	Linked to climate change (possible new diseases). Trade-off between biosecurity and free trade?
Biodiversity	Approaches to conservation under conditions of climate change
Ecosystems services	Approaches to ecosystem science. Policies towards payments for ecosystems services

Table 3.2: Technology

Agricultural technology	New methods, breeds, seeds (GM etc), Integrated Farming, more access to larger machines. Lower carbon farming systems. What sorts of agricultural systems might be promoted?
Energy technology	Technology for the major energy using sectors, especially transport and heating. Technology for energy generation, especially for renewable energy sources, and sources based on land use in particular.
Biofuels	Development of first and second generation biofuels
Information technology	Adoption of IT in farming systems. Implications for consumer information and retail demand patterns.

Table 3.3: Society - Preferences and civil society

Demographic change	Population growth and ageing, migration at global and national levels
Urban / rural balance	Spatial distribution of population and economic activity between different areas
Global food demand	Economic growth stimulates demand for food, especially livestock products
Domestic food demand	Change from supply driven to demand driven supply chain, demand for higher quality food, niche markets, local markets, etc.
Animal welfare	Changing consumer demand for products.
Environmental concerns	Public attitudes towards environmental issues potentially driving government policy at UK and international levels
Land use lobby	Planning, housing, transport, renewable energy demands and constraints
Politics	Political orientation: centralisation v. decentralisation; planning v. markets

Table 3.4: Economy - Markets and prices

World Supply and Demand	Changes in supply and demand for commodities might influence prices and lead to substitution between enterprises. Look up current Institutional Forecasts – (how variable are they over time?) EU land uses more susceptible to swings in world markets with lower levels of domestic protection.
Growth Rates	Unlikely to feed through into major increases in demand for food products, but could expand opportunities for off-farm income.
Exchange Rates	Major impact on profitability of agriculture.
Biofuels	Targets for a certain proportion of energy supplies must come from renewable sources. Renewable Transport Fuels Obligation. EU legislation as well. But questions as to sustainability.
Supermarkets, local sales, assurance	Potential changes in market power and structure

Table 3.5: Politics - UK and international policies

CAP Commodity Reform	Decoupling – Beef, Sheep, Cereals Oilseeds, Pulses. Decrease in milk price and Quotas in place for dairy. Sugar beet price cut and compensation. SFP wholly area based payments by 2012 in England – implications for changes in payment rates across different sectors. Historic payment in Scotland and Wales.
EU Enlargement	Minor impacts on agriculture in the UK – increased competition offset by market access – impact on sterling uncertain. Opportunities for dairy exports, but effects on beef and sheep likely to be negligible. Cereals more impact in longer term. Challenge to EU approaches and competition for EU funds.
Doha / WTO	Uncertain time frame but likely tariff cuts and removal of export subsidies may mean increased competition from imports with subsequent pressures on domestic prices.
Food and energy security	Possible renewed concerns encouraging increased domestics supply of food and energy?
EU and UK government spatial policy	To what extent do the EU and UK government seek to redistribute economic activity against trends towards concentration?
Agri-environmental measures	CAP cross compliance, Environmental Stewardship (ELS and HLS), Less Favoured Area policies. Is the priority to maintain land uses against abandonment or protect against excessive production intensity? What funding may be available in context of CAP reform etc.
Forestry policy	What will the priorities be for policy: environment, recreation, timber, carbon?
Environmental Measures	Environmental legislation (e.g., phase out of certain pesticides). Waste Framework Directive; Nitrate Vulnerable Zones; Rural Development Regulation; Air Quality legislation.

Climate mitigation and adaptation	Policies to mitigate and adapt to climate change
Renewable energy	UK, EU and international targets and incentives, especially biofuels
Land use planning	Housing, urban development, transport and countryside protection

One way of classifying the various drivers, such as has been applied in the Foresight Exercise on Land Use Futures[7] is to locate them within two dimensions relating to their importance and their certainty. Importance relates to their bearing on the issue in question and Certainty to the degree to which it is possible to predict their future levels. This gives four 'domains' (Figure 3.1; Table 3.6):

Predetermined Elements: Drivers that are of importance for future scenarios, but which are effectively predetermined given the present situation.

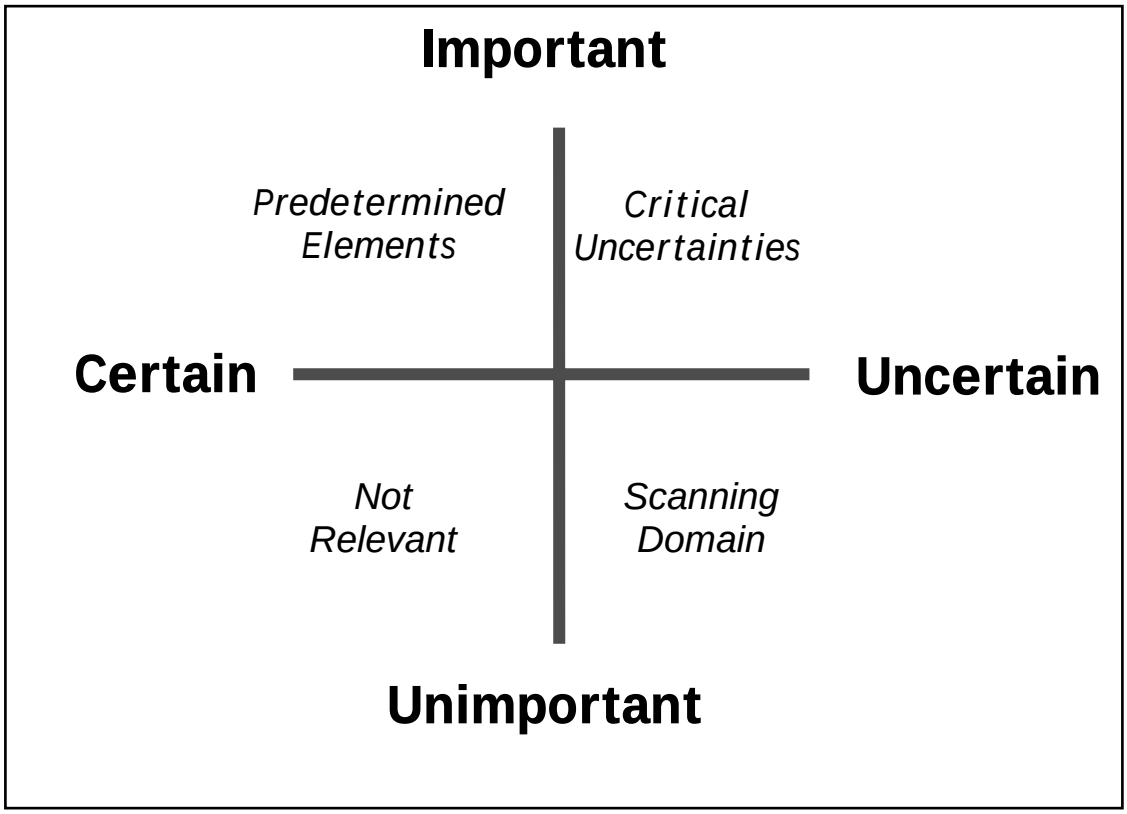
Critical Uncertainties: Drivers which are important but at the same time uncertain. Clearly these are drivers which should be given careful attention.

Scanning Domain: Drivers that appear not to be critical but for which there is significant uncertainty such that they may become critical in the future.

Not relevant: Drivers that are well understood and not relevant to the present focus of attention.

[7] http://www.foresight.gov.uk/OurWork/ActiveProjects/LandUse/LandUse.asp

Figure 3.1: Dimensions of Scenarios



From the drivers identified, we might suggest the following allocations (Table 3.6):

Table 3.6: Allocation of Drivers to the Four Domains

Predetermined elements:	**Critical uncertainties:**
Global population growth	Global economic growth and trade
Ageing population in the UK	World energy and commodity prices
Climate change	Exchange rates (and UK entry into Euro)
Developments in information technology	Trade and agricultural policy liberalisation
Introduction of flat rate Single Farm Payment (and erosion of its value)	Government climate and energy policy
Water Framework Directive	Forestry policy
	Security concerns
	Animal and human health

Not relevant:	Scanning domain:
Logically, of course, drivers that are 'not relevant' are not, in fact, drivers at all!	Growth of rural populations Site-based conservation policies Demand for high quality food products and local markets Markets for SFP entitlements Requirements to meet WFD standards Carbon trading opportunities Developments in energy generation technology GMOs 'Reference level' for environmental quality

Unknown drivers

Beyond the drivers that we can recognise now as being of potential importance, we also need to recognise the 'unknown unknowns'. These can be of major significance but clearly cannot be predicted. An example would be the case of BSE in the 1980s which was previously unknown but which had major impacts on livestock producers. It would seem that such surprises might be more likely in the future in the contexts of climate change, disease risks or international security. These unknown shocks to the system can have major consequences and any discussion of the future must recognise their potential to alter outcomes and hence the limits of what can be analysed at any particular time.

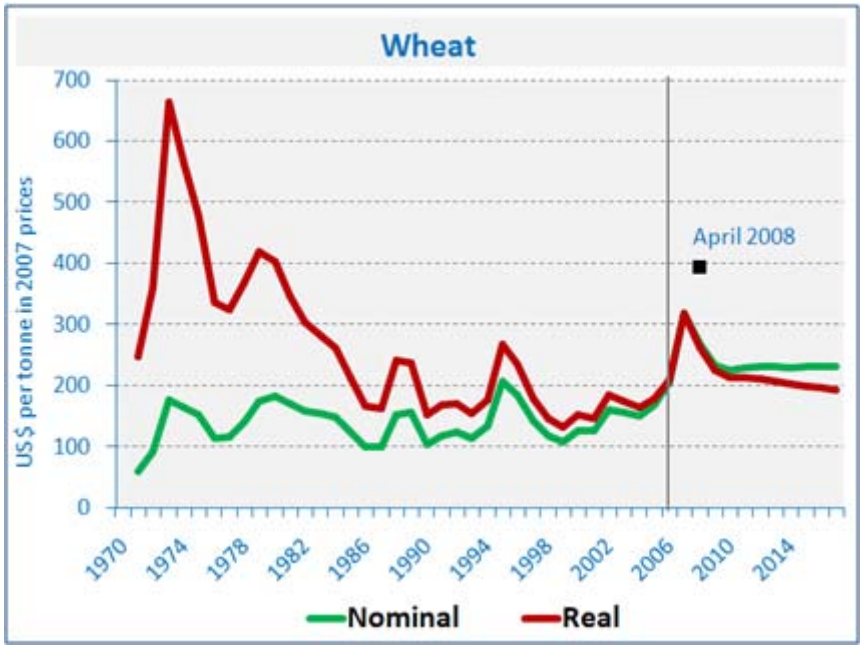
It is not possible to discuss a significant proportion of these drivers in any detail, but from amongst them we concentrate on three sets of drivers that we believe to be of particular significance: commodity prices, agricultural policy and climate change.

3.2 Commodity prices

Agricultural Commodities

The most fundamental determinant of the financial returns to agricultural land is the price received for agricultural commodities. Figure 3.2 demonstrates the dramatic increase in world wheat prices that has occurred in recent years and this reflects the pattern of price increases of commodities more generally. It comes at the end of a long period over which food commodity prices have seen a steady decline that many had assumed would continue further into the future. But it is placed in a longer term perspective that indicates that while the recent increase is dramatic, the level of prices achieved remains well below that attained in real terms through the 1970s and 1980s.

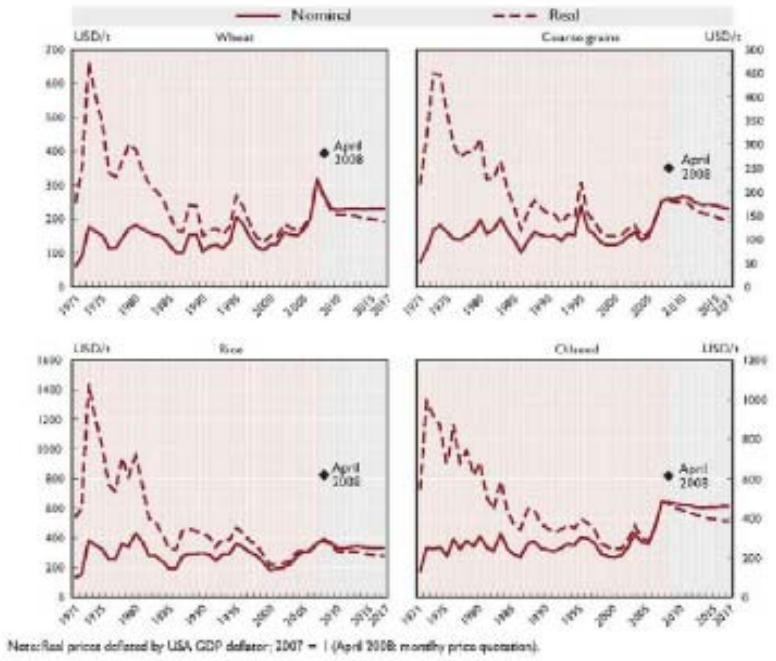
Figure 3.2: Trends in Wheat Prices



Source: OECD (2008) *Agricultural Outlook 2008-2017*, OECD, Paris

Figure 3.3 shows that there is a similar pattern for a variety of agricultural commodities.

Figure 3.3: Food commodity prices, 1971-2007 with projections to 2017

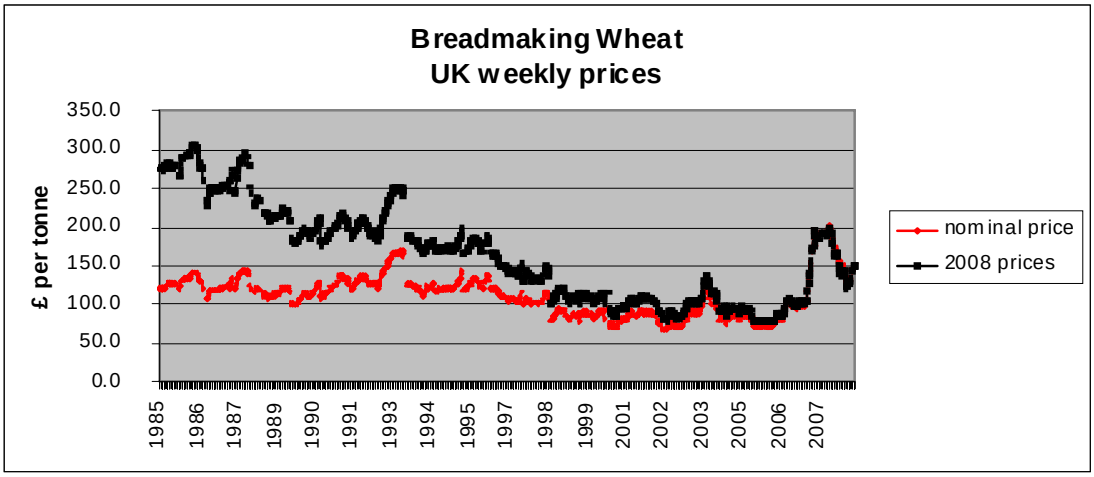


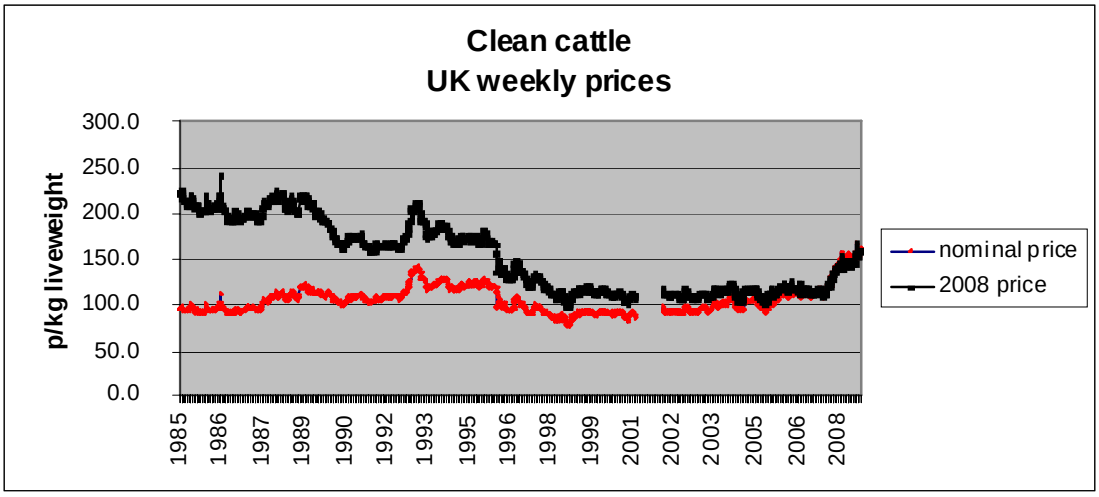
Source: OECD and FAO Secretariats

Crown Copyright
Source: HM Treasury (2008) p44.

One prior issue relates to whether world prices are transmitted into UK markets. Technically, UK prices might be isolated from world prices through the operation of the Common Agricultural Policy. Historically the Common Agricultural Policy (CAP) has operated almost exclusively to maintain prices within the European Union above those in world markets although the mechanism has in principle had the potential to hold prices down should world prices be excessively high. The implementation of this approach seems very unlikely in the future given the pressures to dismantle commodity market intervention and the lack of political pressures to do so. We discuss the role of agricultural policy in the next section. Thus UK cereal prices have mirrored the trends in world prices as illustrated in Figure 3.4. We should note two further points from the Figure: that most recently there has been a significant decline from the peak price level reached in 2007 and that, again, in real terms, prices are not high compared with prices experienced in the 1970s and even 1980s. However, prices have not fallen to the level typical in the first half of the 2000s. The cattle price shows a rather different pattern, having failed to rise in 2007-08 but now showing a marked increase.

Figure 3.4: Breadmaking wheat prices 1986-2008





Source: derived from data from Defra deflated by the RPI

Over the past decades since the 1980s, we have seen a steady, albeit uneven decline, in the levels of real commodity prices. There have been period of price rises but these have quickly been reversed back to the general trend of decline. So, is the present experience different? Can we expect that the present price hike will again relapse back into decline? As can be seen from Figure 3.2, the OECD projects that while wheat prices will ease somewhat, they will remain higher that in recent years over the period to 2017. The key question of whether the generally higher world commodity prices will persist into the future clearly depends on the reasons for the recent higher prices and whether these factors will persist in the longer term. The issue has been extensively discussed, such as by Banse *et al*. (2008) or HM Treasury (2008).

Three factors may suggest that prices can be expected to revert to the historic declining trend:

- the recent higher prices are associated with short term and unusual climatic effects, poor harvests in 2006 and 2007, especially drought in Australia, that have already changed;
- temporary government policy responses to high prices seeking to reduce their own domestic prices that have exacerbated the problems at the global level. The IMF has estimated that export restrictions in some of the major rice exporters may have accounted for as much as half of this year's price increases (HM Treasury, 2008, p34);
- the recent events and prices both in terms of commodities and financial sectors have prompted unusual speculation in commodity markets that has driven up prices (the current price increases represent a 'bubble'). The Treasury has recently commented that "taken together the available evidence suggests that derivative investors are not driving price increases and, although there is insufficient evidence to conclusively rule out any impact, it is likely to be only small and transitory relative to fundamentals in demand and supply for the physical commodities" (HM Treasury, 2008, p25). However, it may be noted that other commentators take a less sanguine view.
- we can expect a significant supply response to increase world supply that will bring prices back towards their historic trend.

On the other hand, there are strong arguments that the generally higher prices are different from previous occasions and that they may signal a long term change. Some arguments being made are not different from the past; notably the argument of an increasing global population against a finite land area has been a familiar one since at least the time of Thomas Malthus and recently echoed by Beddington[8]. It has not proven to be the case in the past, but of course, that does not mean that it cannot be the case now, and it must be accepted that in some senses at least the physical capacity of resources available for food production is finite. But it does urge caution that dire predictions for global food supplies are quite familiar. Nevertheless, there are good arguments that the present position is at least somewhat different:

- The strength of the economic growth, especially in the BRIC economies, means that the global demand for agricultural commodities will continue to grow, especially as income levels stimulate increased demand for livestock products which in turn demand substantial amounts of cereals;
- Concerns about climate change and energy security have led to policies to stimulate the production of biofuels, quite spectacularly in the United States, that are and will continue to compete for land that would otherwise be used for food production.
- The a changing climate is itself directly destabilising the environmental conditions within which agriculture is practiced and undermining yields;
- We have been through a period, especially in Western countries, where the level of research into agricultural productivity has been substantially curtailed such that there are declining levels of growth in agricultural productivity. The evidence on UK wheat yields illustrated in Figure 3.5 offers some evidence for this. Over the long term, the growth in yields has followed an exponential rate of growth, but when looked at over a more recent period, the pattern would appear to have reached an upper limit. There has been a similar experience with other crops; for instance, oilseed rape yields have fallen by 2% over the past 15 years. Evidence presented by Alston (2008) persuasively suggests that the slowing rate of growth in agricultural yields is closely associated with a reduction in investment in agricultural production research.

Figures 3.5 and 3.6 show data on the long term level of wheat yields in the UK

[8] Beddington, John (2009) Speech at the Sustainable Development UK conference, London, 19 March, 2009

Figure 3.5: Wheat yields in the UK, 1885-2007

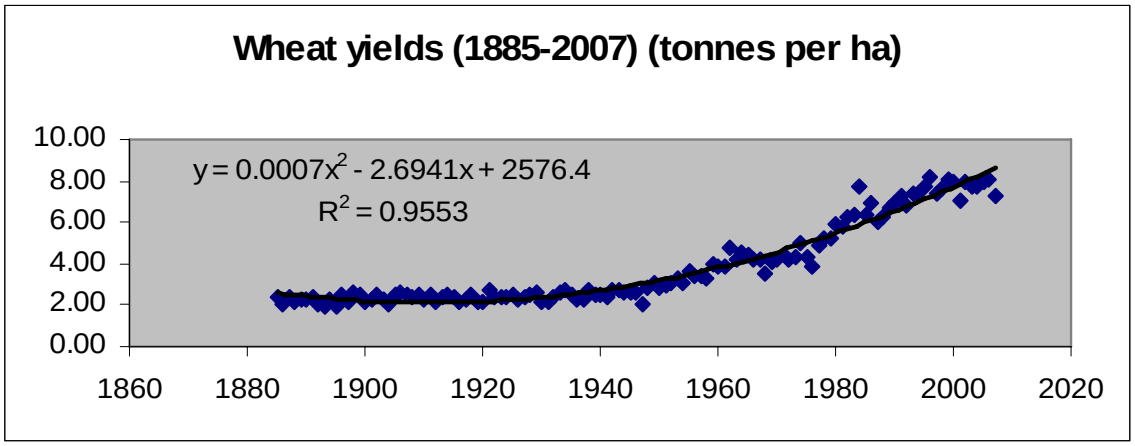
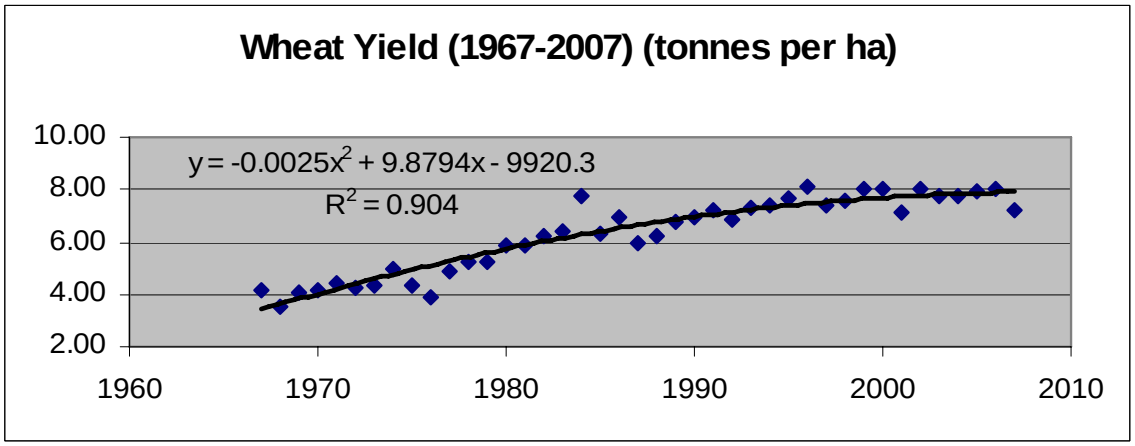


Figure 3.6:: Wheat yields in the UK: 1966-2007



Taken together, these factors do suggest that while we may see some easing of commodity prices over the coming couple of years, there must be a strong probability that we will experience a period of relatively higher commodity prices in the longer term that is quite different from the experience that has dominated the past fifty years. This is a common perspective and it will thus be important to consider what implications this may have. But the prospects remain uncertain and the recent fall in certain prices is already questioning whether prices may indeed revert to their historical decline.

Price of oil

The price of oil is especially difficult to predict, even in the short term. Thus for example, the Treasury has reported independent forecasts for the price of crude oil for September 2009 that range between around $80 and nearly $180 per barrel (HM Treasury, 2008, p39). In the long term it was anticipated that there will be continuing growth in the demand for oil, primarily from the emerging economies but that there are sufficient reserves to meet this rising demand at least until the 2030s. However,

some concerns were been expressed that there has been and will continue to be insufficient investment in the supply chain and that unless there is a collapse in oil demand in the next five to ten years, that there will be a serious oil 'supply crunch' (Stevens, 2008). This could lead to a price spike that could take prices to $200 per barrel. It is argued that this could arise around 2013. In practice, we have seen a significant decline in demand and the oil price fell below $40 per barrel at the start of 2009 and is currently trading around $45, with some forecasting further collapse to $25. The conclusion must be that we are unable to forecast prices with any confidence within a very wide range.

Exchange rates

A final factor with regard to commodity prices concerns the level of exchange rates. Domestic businesses are concerned with values in terms of £ sterling, while many global commodity prices are set in terms of US$. Thus the level of the exchange rate also becomes a critical variable in determining the levels of prices faces by British producers. Again, it is not possible to project an exchange rate over 20 years, rather we need to bear in mind that there is a further uncertainty involved.

The implication is that in the longer term real commodity prices are likely to be higher than their historical averages, driven by strong demand and increasingly constrained supply response, but perhaps lower than the recent prices spikes that have been seen for several commodities. The recovery of prices will depend on the speed at which the global economy moves out of recession, but we must anticipate more frequent and substantial price fluctuations

3.3 Agricultural policy

Over the past decades, agricultural returns have been substantially determined by the operation of agricultural policy. Under the Common Agricultural Policy (CAP) output prices have been both maintained at relatively high levels relative to world market prices and insulated from changes in world prices. While this has had the intended effect of promoting domestic European production, it has also caused many and varied problems both within the European Union, such as the budgetary cost of operating the policy, and internationally, such in terms of the impacts on world trade. In this context, there has been a gradual but fundamental liberalisation of the way in which the CAP operates, through restraint in the 1980s, partial decoupling in the 1990s to 'full decoupling' in 2005.

Further less radical reforms have been introduced under the CAP 'Health Check' completed in 2008. This has added some further decoupling, abolition of set-aside, phasing out of milk quotas by 2015 and some further modulation, transferring funds from Pillar 1 to Pillar 2. The EU has also offered to phase out export subsidies in the context of the Doha round of world trade negotiations, and it has been reported that this may not be dependent on the successful conclusion of the Round, which now looks extremely unlikely. This may be achieved by 2013. The level of finance available for Pillar 1 of the CAP is currently fixed up until 2013 and attention is now being focused on policy reform beyond that date.

The longer term development of agricultural policy will take place within a different economic and environmental context. The UK government has set out a clear vision of a considerably more liberalised agricultural policy HM Treasury and Defra (2005), the main elements of which are:

- Free fair and level playing field for farmers
- Focus on maintaining environment and promoting sustainable rural development
- Long-term, targeted, non-production distorting measures
- Import tariffs aligned with lower levels in other sectors
- No price support, export refunds or other production or consumption subsidies
- Social and welfare benefits to farmers on same basis as other members of society
- Spending supporting appropriate (public good) objectives

The UK's vision aims by 2015-2020 to have cut agricultural tariffs to the levels that prevail on industrial goods, to have eliminated all market management measures such as intervention and export subsidy, and all direct payments (HM Treasury, 2008 p64). As a start towards this, the government notes that permanent elimination of set-aside and the elimination of dairy quotas under the EU's Health Check could lead to a reduction in prices. The government has also aimed to agree an ambitious Doha Development Agenda world trade deal, but at this stage the prospects for agreement on any radical reforms seem very poor. This makes the point that the UK government vision may not be shared by other countries, either within the European Union or more widely globally, and so may not define the progress that is made in practice.

However, the UK government's view is not widely shared amongst the other member nations of the EU and so is unlikely to be realised. The enlargement of the EU to 27 members has re-emphasised the significance of agriculture within the EU economy, for instance, more than a third of employment in Romania is in agriculture. The position could be further complicated by the possible membership of Turkey some time around 2015 and ex-Soviet states, such as Ukraine, before 2028. The admittance of new members has generally been based on political rather than economic arguments and the present diplomatic issues with Russia may make closer relationships more likely if it is seen as a means of securing democratic gains. And, of course, any radical change in policy in the EU is extremely difficult to achieve, as illustrated by the efforts to establish a new constitution and the subsequent attempts to implement the Lisbon Treaty.

However, at the same time the present CAP may seem unsustainable. The Single Farm Payment may be argued to lack a credible rationale, either as compensation for past policy changes or as a payment for environmental management. The balance of payments towards the older member states contrasts with the requirements for agricultural modernisation and rural reform in the newer member states. The EU member states face a multitude of environmental commitments (Cooper, et al., 2008), set at both global and EU levels, for which there will be demands on agricultural policy expenditure.

In the current context of higher commodity prices, there is a renewed case being made for a return towards a more productivist approach to agricultural policy, illustrated for

instance in the debate last year between Peter Mandelson, the then European Trade Commissioner and French President Nicolas Sarkozy as to the approach that should be taken to the World Trade negotiations. There is certainly renewed focus on food security, now coupled with the question of energy security, that potentially merges into a demand for an increased level of domestic production and reduced imports. And it has to be admitted that there may be some apparent contradiction in the arguments for liberalisation which have in the past been made that reduced agricultural protection would tend to reduce the level of subsidised exports to world markets and so increase prices and trading opportunities for agriculture in developing countries, to the present argument that freer markets will tend to bring lower world food prices.

In the medium term at least, it does seem likely that there will be some further aspects of liberalisation associated with the decoupling of farm payments, elimination of export subsidies and a reduction in the level of tariff protection with regard to agricultural production that will make European farmers more exposed to the volatilities of world market prices. We also anticipate that climate change will be associated with greater variability in terms of weather and the environment within which agricultural production takes place. At the same time, the level of funding available to the CAP, especially for agricultures within northern European member states, seems likely to decline post 2013. There is however some degree of support around the idea of 'public goods for public money' (Baldock, 2008) and in the context of EU decision making processes, we would not expect a simple transfer of funds from one area to another without some offsetting elements being imposed as a basis for achieving agreement. We can thus anticipate that some substantial elements of agricultural policy will continue. Arguments for this will be supported by concerns for food and energy security against the anticipated generally higher level of commodity prices and concerns as to the potential vulnerability of food and energy supply networks. But of course, the precise level of the policy in terms of funds available and the extent to which these benefit agricultural systems and land uses in Great Britain must be uncertain.

The policy seems very likely to continue to include a version of agri-environment policy based on the provision of public goods or ecosystem services similar to the approach that has been delivered to date. This could potentially be at a higher level that has been the case in the past, although any increase is likely to be more than offset by reductions in the present Pillar 1 payments. However, the orientation of an agri-environment policy may well change so as to give a greater emphasis to: mitigating and adapting to climate change; soil and water conservation in order to protect the productive capacity of agricultural and rural resources; and to actions to mitigate and adapt to risks and natural disasters. It may also be the case that given the challenges associated with the development of incentive policies in order to reduce GHG emissions from agriculture that an agri-environment approach offers the most realistic option, especially in the medium term.

On the face of it, the most efficient means of delivering these sorts of objectives would be through the operation of carefully targeted programmes under Pillar 2 of the CAP. But targeting a given volume of funds means that some sectors and areas will loose out and so this may be challenging politically. An alternative might be to introduce more elements of conditionality into Pillar 1, perhaps by increasing the

cross-compliance requirements or varying the allocation of funds by region of agricultural system.

The progress towards the liberalisation of agricultural policies has seemed secure. At the present time increased border protection or domestic market support for agricultural commodities, notwithstanding the failure of the Doha Round, seems unlikely. But of course it is not impossible and the motivation might arise from countries other than those which have tended to protect their domestic agricultural sectors in past years. As countries become more developed, they may choose to protect their own agricultural systems in order to make their food and energy supplies more secure and to guarantee their domestic food supply. While this is less likely to occur in major food and energy exporting countries, it may well be a policy option for a country such as China at some point in the future, driven by a desire to improve conditions in rural areas as against rapid urban growth. This might potentially have a significant impact on the development of global commodity prices. However, we believe that this is not particularly likely over the coming 20 years.

3.4 The climate change context for the UK

At present the most up-to-date scenarios of climate change impacts for the UK are the UKCIP02 scenarios. These scenarios provide four alternative descriptions of how the climate of the UK might evolve over the course of this century. The differences between the scenarios result from uncertainty regarding future trends and behaviour, such as population growth, socio-economic development and technological progress, and how these might affect future global emissions of greenhouse gases. UKCIP02 scenarios are generated from a climate model developed by the Hadley Centre in the UK. They were commissioned by Defra to provide a common starting point for assessing climate change vulnerability, impacts and adaptation in the UK. Further scenarios based on more recent climate projections will become available in due course. These will provide an even greater level of detail and will better information in probabilistic terms. Information is available via the UKCIP (UK Climate Impacts Programme) website, www.ukcip.org.uk.

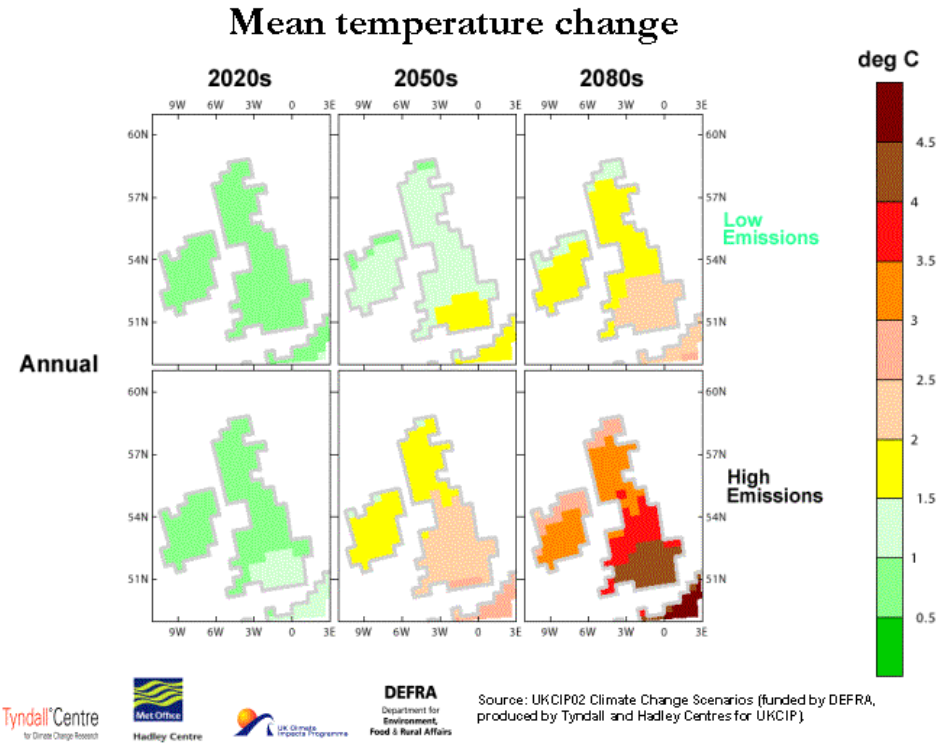
The impacts of climate change on agriculture come about through changes in variability, seasonality, changes in mean precipitation and water availability, and the emergence of new pathogens and diseases.

Main messages for the UK

Thermal growing season for plants has increased by up to 30 days since 1900 and is expected to lengthen, but soil moisture levels in summer and autumn are expected to decrease. By 2040, average annual temperature for the UK is expected to increase by 0.5 and 1 degree C, depending on region. However average annual temperature masks seasonal differences. In the UK, there is expected to be greater warming in the summer and autumn than in winter and spring. By 2040, average summer temperature for the UK is expected to rise by between 0.5 and 2˚C, depending on region, while average winter temperature in the UK is expected to rise by between 0.5 and 1˚C.

Figure illustrates the expected mean temperature changes across the UK for low and high emissions scenarios, for the 2020s, the 2050s, and the 2080s. While the 2050s and 2080s are outside the time frame of this report, an understanding of the likely direction of future changes is important for decision-making. It can be seen that by the 2020s the temperature increase is relatively even across the UK, at around 1˚C for most of the country with a slightly greater increase in the South East under a high emissions scenario than the rest of the country. By the 2050s however there is greater differentiation even under the low emissions scenario, mostly around 1˚C with the south east possibly reaching 2˚C, and the north of Scotland and northern Ireland remaining at 1˚C. Under a high emissions scenario, even most of Scotland and Ireland are expected to have a mean temperature increase of around 2˚C, while England and Wales may see increases of 2.5˚C to perhaps even 3˚C in some areas. These increases are exacerbated through to the 2080s and beyond.

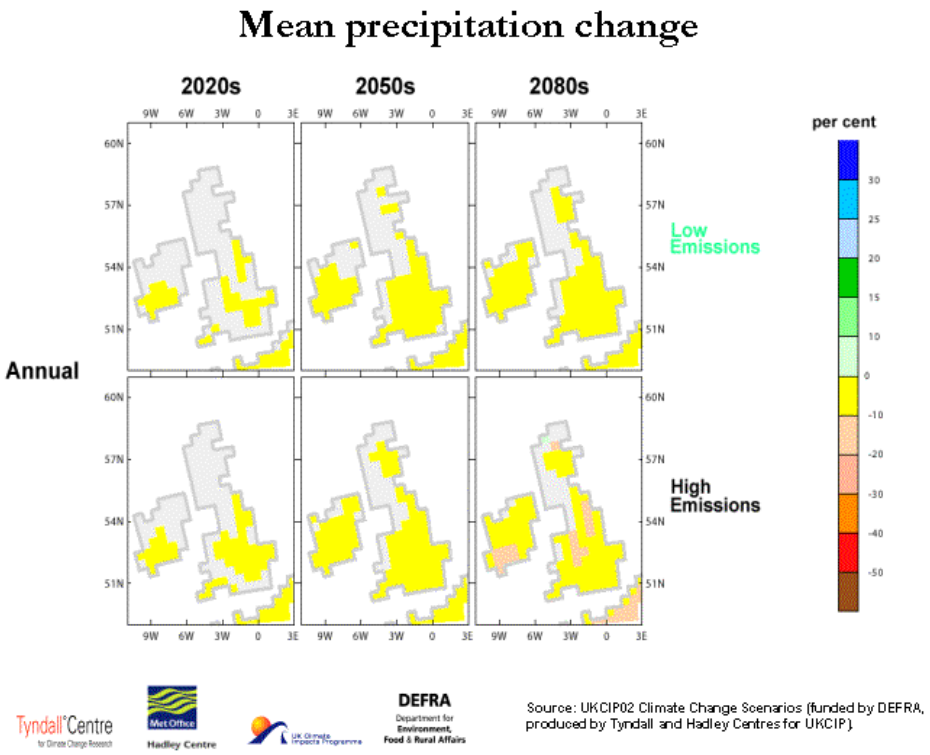
Figure 3.7: Mean temperature change



By 2100 there is expected to be up to 30% more precipitation in the winter months depending on region and emissions scenario, however summer precipitation is expected to decrease (by 2100 this is expected to be up to 50% less precipitation in summer months). Figure 3.8 illustrates the expected mean precipitation changes for the UK under low and high emissions scenarios, again for the 2020s, 2050s, and 2080s. Precipitation is less certain to project than temperature (Hulme *et al.*., 2002), however these figures provide an indication of likely changes. It can be seen than that general trend over time is for a decrease in mean precipitation, particularly in the eastern and southern parts of the country (by around 10 percent). Up to the 2020s the decrease is still restricted to certain areas, even under a high emissions scenario,

however by the 2050s the decrease is more widespread. Only the very western parts of Britain and areas of Scotland are not expected to experience a decrease in rainfall by the 2050s.

Figure 3.8: Mean precipitation change



However as mentioned, mean temperature and precipitation changes mask seasonal changes, and while there may be a mean decrease in rainfall, it is likely to occur in more intense bursts, and winters are expected to become wetter. Snowfall amounts are expected to decrease across the UK and large parts of the country are expected to experience long runs of winters without snow however heavier winter precipitation is expected to become more frequent. The number of very cold days is expected to decrease but there are also likely to be more winter storms. In general winters in the UK are expected to be milder, wetter and windier.

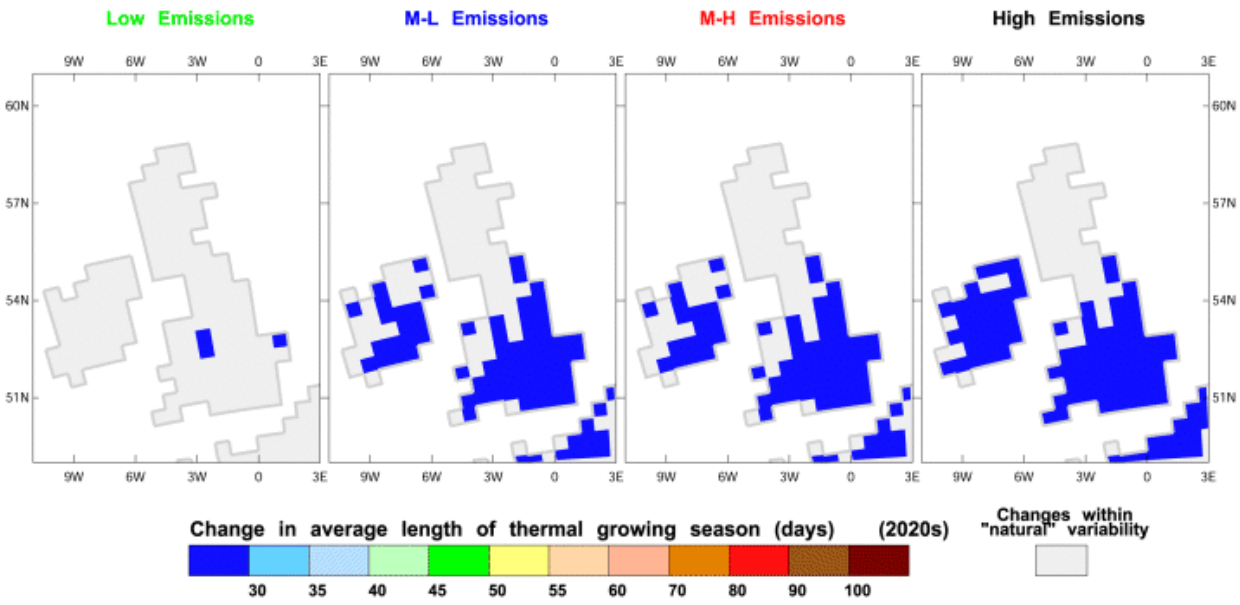
Summers on the other hand are projected to become hotter: the number of very hot summer days is expected to increase, and high temperatures similar to those experienced in August 2003 or July 2006 are expected to become common by the end of the century, even under the low emissions scenario.

Sea-level rise is also projected for the UK, although it is expected to be greater in the south of England than in western Scotland due to variations in natural land movements. Extreme sea levels are expected to be experienced more frequently.

Figure 3.9 and 3.10 illustrate the projected change in Thermal growing season by 2020 (Figure 3.9) and 2050 (Figure 3.10). By the 2020s, there will be some changes in growing season days, depending on scenario. By the 2050s, the increase in

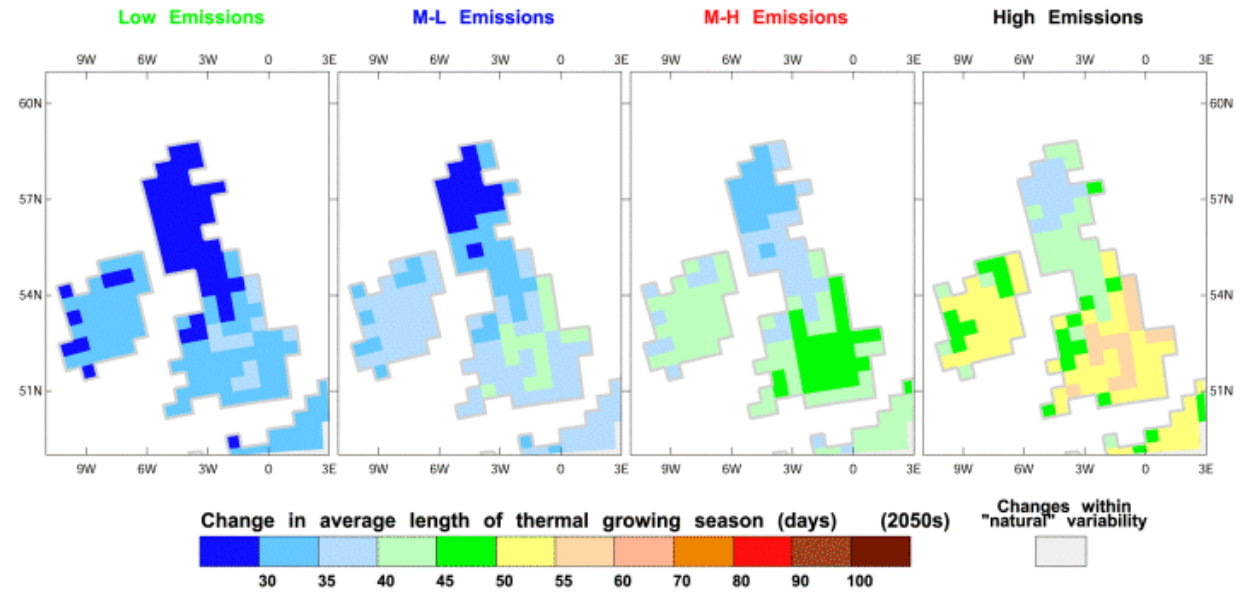
growing season days is projected to be much more pronounced, with some areas increasing the length of the growing season by 50 – 60 days under a high emissions scenario. The term "growing season" in this context does only refer to temperature and does not account for water availability or day-length. Drier summers together with the same daylight hours as today's means many plants may not be able to take advantage of the longer theoretical growing season.

Figure 3.9: change in thermal growing season (2020)



Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Figure 3.10: Change in thermal growing season (2050)



Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

More detail and more graphs can be obtained on the UKCIP website (www.ukcip.org.uk).

Which scenario is more likely?

More recent research seems to point towards more rapid change than has been anticipated in the past. A recent poll of climate scientists[9] found that the overwhelming majority did not believe that political efforts to restrict global warming to 2°C by the end of the century will succeed. The more commeon expectation was for 4-5°C. However, differences between emissions scenarios have relatively little effect on the climate that will be experienced in the next 30 – 40 years. The climate will warm by approximately the same amount in each case because changes in this time period have been determined by historical emissions. The differences between scenarios take effect in the longer term, therefore for the time-scale being considered in this report, the differences between scenarios are not so significant. More significant will be whether governments become sufficiently alarmed at the potential consequences of climate change so as to implement major policy innovations.

Implications of the projected changes for agriculture in the UK

These changes in climate will have implications for the way in which producers in the UK are able continue their practices and production methods. Some of the changes may be positive, while others are likely to have negative impacts on production and existing practices. There are various sources of uncertainty in the impacts of climate change on agriculture. First, these concern the rate and magnitude of climate change itself. Second, there are uncertainties around the biological response of agricultural outputs, for example with regard to CO_2 fertilisation. Third, there are uncertainties regarding how society responds or has the capacity to respond to projected and expected impacts.

The main effects will be discussed in general terms below, and the implications for The Crown Estate land will be discussed in a subsequent section.

Carbon Dioxide (CO_2) effects

Although not a change in climate *per se*, the elevated CO_2 levels driving the climatic changes will also have an effect on plant growth. CO_2 effects increase with temperature, but decrease once optimal temperatures are exceeded for a range of processes, especially plant water use. The CO_2 effect may be relatively greater (compared to that for irrigated crops) for crops under moisture stress. However temperature and precipitation changes in future decades will modify, and often limit, direct CO_2 effects on plants. For example, high temperatures during flowering may lower CO_2 effects by reducing grain number, size, and quality. Additionally, increased temperatures may reduce CO_2 effects indirectly, by increasing water demand.

Grasslands can also be sensitive to CO_2 and areas in upland Britain which are already colonised by relatively unpalatable plant species such as bracken, matt grass and tor grass, may see an increase in these species under elevated CO_2 levels, which could have detrimental effects on the nutritional value of extensive grasslands to grazing animals.

[9] David Adam 'World 'will not meet' 2C warming target' *The Guardian* 14 April 2009.

Mid- to high-latitude crops are likely to benefit from a small amount of warming (about +2 degrees) but plant health decreases with additional warming.

Mean warming

A mild warming generally increases grassland productivity, with the strongest positive responses at high latitudes.

However, a decrease in precipitation will have impact on plant water requirements as well as irrigation water requirements

Extreme events (drought, heat wave, flooding, storm)

Thermal stress reduces productivity, conception rates and is potentially life-threatening to livestock. Increased heat often results in declines in physical activity and associated declines in eating and grazing activity. High temperatures put a ceiling on dairy milk yield regardless of feed intake. Conception rates, particularly in cattle, in which the primary breeding season occurs in the spring and summer months, will potentially be affected by increases in air temperature or humidity.

Animals not adapted to high temperature are particularly affected by climate variability. Cattle in confined feed-lots often show catastrophic losses, with economic losses from reduced cattle performance exceeding those associated with cattle death losses by several-fold. With increased heat stress in the future, water requirements for livestock will increase significantly from the present.

Extreme events may also make the timing of field applications more difficult, thus reducing their efficiency. It has been calculated that under scenarios of increased heavy precipitation, production losses due to excessive soil moisture would double in the US by 2030 to US$3 billion per year.

Other extreme events such as flooding and windstorms, may also have serious detrimental effects on agriculture.

Pests

CO_2- temperature and precipitation interactions are recognised as a key factor in determining plant damage from pests in future decades. For example, recent warming trends in the US and Canada have led to earlier spring activity of insects and proliferation of some pest species. Additionally, increased climate extremes may promote plant disease and pest outbreaks, as well as facilitating the spread of animal diseases and pests from low to mid-latitudes (such as blue-tongue, which mostly affects sheep, and occasionally goat and deer, which would continue to spread from the tropics to mid-latitudes).

Other

Multiple stresses, such as limited availability of water resources, loss of biodiversity and air pollution are increasing sensitivity to climate change and reducing resilience in the agricultural sector.

Efforts to reduce vulnerability and facilitate adaptation to climate change are influenced both positively and negatively by changes associated with globalisation.

Implications for production

Table 3.7 shows the estimated average yield change and estimated yields for selected crops in the UK from the current climate to the HadCM3 A2 scenario of climate change in 2050 (The A2 scenario describes a very heterogeneous world with high population growth, slow economic development and slow technological change, by 2050). While the estimates presented here appear to be positive in isolation, they only involve the changing climate and do not consider changes in socio-economic scenarios that actually drive climate change. Change in the price of energy, or policy reform and its effect on support can potentially swamp the impacts of climate change. Nor do they consider the impacts of increased extreme events.

Table 3.7: Average yield change and estimated yields for selected crops in the UK between the current climate and one scenario of climate change for 2050 (Audsley et al. 2006)

	W Wheat	S Wheat	Maize	Potatoes	Sunflower	Grass/Silage
North East	22%	32%		39%	2.3t/ha	25%
East	25%	25%	6.2t/ha	43%	40%	24%
South West	15%	11%	8.2t/ha	38%	50%	19%
North	15%	28%	8.4t/ha	27%	3.6t/ha	7%

3.5 Forestry

Drivers of Change to 2028

Climate change: Impact

Much effort is being devoted to trends and forecasts of climate change – globally and in local areas – and the likely impacts on patterns of land use. Whatever steps may be taken in mitigation, some further change is inevitable. Elsewhere in this report there is a summary of the main messages for the UK. Thermal growing season for plants increased by up to 30 days during the 20th Century, and is expected to lengthen further. By 2040, the average annual temperature is expected to increase by up to 1˚C, with rather greater warming in summer and autumn than in winter and spring. While winter precipitation is expected to increase, the main forecast is of less summer rain and an overall annual decrease. From a forestry perspective, such trends over the next few decades may not have a very significant direct effect: what may well be more important is the frequency and intensity of 'extreme events'. More frequent summer droughts and winter storms, with higher wind speeds in the latter, may

necessitate some modification of forest species choice and/or silvicultural methods in a limited number of parts of The Crown Estate.

The majority of the trees which will be growing on The Crown Estate twenty years from now are already in place, and it is to be expected that most of them will be growing as well as they are now. On the more exposed upland sites, more severe winter storms are likely to increase the incidence of windthrow, which may disrupt harvesting and thinning plans. This trend may be countered to some extent by changes in the size and shape of felling coupes, and by modification of planting distances and thinning regimes. Such adjustments may be made in the light of experience and may not significantly affect the financial performance of the forests.

Lower annual precipitation and more frequent summer droughts could have a significant effect on the yield class of a few timber species in limited areas e.g. Douglas Fir may become less suitable in the Dunster forest, but the effect is not likely to be great for the next few decades. More significantly perhaps, a succession of summer droughts may reduce a tree's resistance to disease and lead to a deterioration in the health of plantations over a period of time – possibly even to the extreme case of necessitating premature felling of a species and its replacement with a more resistant species. Perhaps less likely, an increase in winter snows coupled with frosts which result in snowload building up on trees could result in damage from broken branches and toppled trees, particularly with strong winds.

The traditional role of upland forests in providing shelter for livestock may become more important locally, and result in some change of use between agriculture and forestry in limited areas.

Within the time scale of this study, however, the direct impact of climate change on The Crown Estate forests is likely to be small, but the forestry staff will be looking out for signs of stress and change which could require management action. Some adaptation may be necessary over time.

Climate Change: Mitigation

In global terms, it may be argued that changes in forest management in the UK, and the establishment of some additional plantations, will have an insignificant effect on climate change. The government, however, is committed to actions to enable the UK to play its part in addressing what is viewed as a major world threat. Forestry is expected to play a role in achieving national carbon saving targets, thereby making a contribution to meeting the global challenge. Trees represent important carbon sinks and a growing forest is an easy means of carbon sequestration, but Defra and the Forestry Commission have expressed some scepticism over the extent of the contribution achievable from new woodland creation in this country (e.g. *A Strategy for England's Trees, Woods and Forests, 2007*).

The Forestry Commission Scotland *Climate Change Action Plan* (2008) offers proposals for the following:

- Protecting and managing existing forests through sustainable forest management, conserving carbon stocks, and minimising deforestation.
- Creating new woodland to capture carbon, produce wood and help adaptation.

- Adapting to climate change by planning and managing forests and woodlands in a way that minimises future risks from climate change, for example through the creation of forest habitat networks, and using different timber species or silvicultural systems.
- Promoting the use of sustainably produced wood for energy and construction.
- Reducing the forestry sector's carbon footprint.
- Raising awareness and understanding of climate change and how forestry can make a positive contribution.
- Measuring progress.

The above goals appear to contain some inherent contradictions, and the general thrust of policy is not entirely clear. Does 'minimising deforestation' while 'producing wood' and 'promoting the use of sustainably produced wood' mean essentially continuous cover management in all circumstances? Or is wood production to be constrained?

Many current carbon offset schemes appear to be of uncertain and unproven usefulness, but what can a large estate achieve within its boundaries in addition to any national or international contribution? Research is underway on The Crown Estate into the impact of different approaches to forest management on carbon capture, and the results of that study should provoke discussion not only on forest management systems and methods but on implications for other parts of The Crown Estate, including urban areas. What are the possibilities of carbon offset within The Crown Estate? Can The Crown Estate forests 'trade carbon' with urban development schemes? Can a 'whole farm' approach to environmental management be extended to a 'whole estate' approach? Is this one issue on which The Crown Estate can readily demonstrate its commitment to sustainability goals and exemplary management?

National forest policies

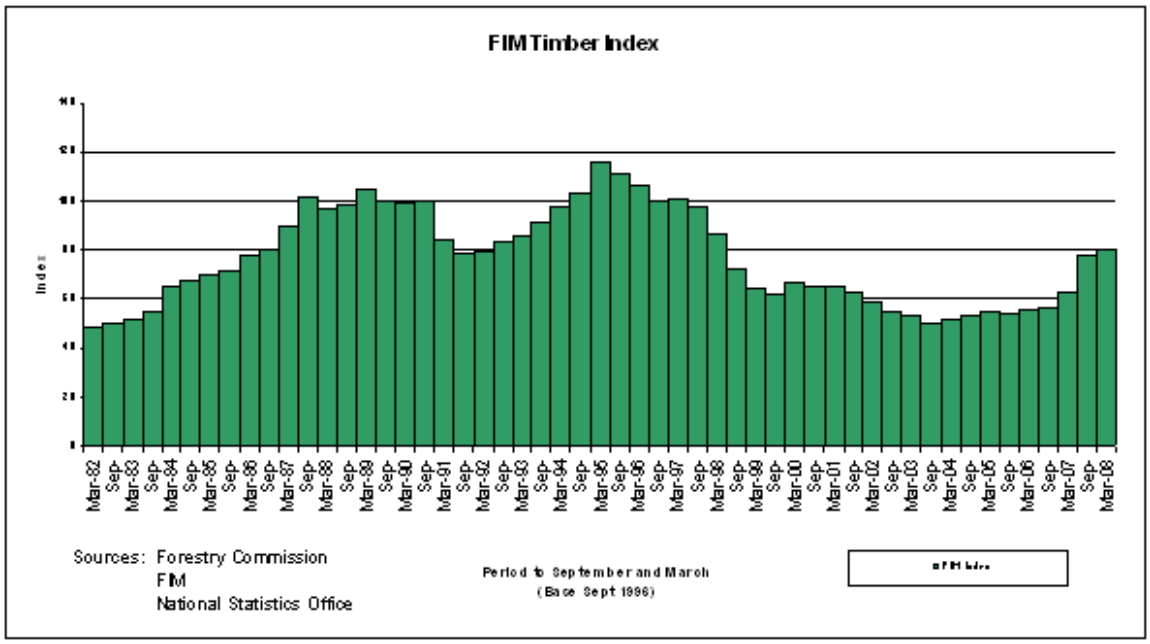
There is now a clear distinction between forest policies for the component parts of the UK. *A Strategy for England's Trees, Woods and Forests* (2007) puts the emphasis on multi-purpose forestry to achieve a variety of public goals but, by comparison with the previous (1998) strategy for England, there is a welcome increased acknowledgement of the importance of 'working woodlands' and 'viable business activity' for the delivery of the government's objectives. For Scotland, commercial timber production and processing has a sharper focus in policy documents. The government's assumption is of a continuing increase in the forest area in all the constituent parts of the UK, without setting specific targets.

It seems likely that the current emphases of national policies will remain much as now, with some periodic adjustment of priorities among public goals, but fundamental change will depend on new economic and environmental imperatives.

Given the current range of objectives for forestry on The Crown Estate and the strong ethos of social responsibility, it is unlikely that there will be significant conflict arising from national policy goals.

Timber trade

Figure 3.11: Timber Index



Commercial conifer investment is so closely linked to international timber prices that it has been described[10] as 'commodity play'. The UK produces only 15% of its timber requirements, importing the rest from overseas; Sweden, Finland and Latvia provided the majority of imports of sawn softwood to the UK in 2006. Sawn hardwood was most commonly imported from Latvia and the USA.

The Forestry Commission's coniferous standing sales index shows that timber prices rose by 35% in 2007, a dramatic step in the recovery from the low point in 2003. Commentators note that there has been a cooling in the market in Q4 2007 and throughout 2008; it is thought that the market has peaked. The chart shows that the price level is still less than 80% of the peaks in the late 1980s and mid-1990s.

As recently as 2004, international trade tended to take place within one of three major trading areas – North America, the European Union and Asia-Pacific. Thus the economies of wood-consuming countries in Europe had the major impact on the price of timber in the UK market. Today, however, the UK price is affected by truly worldwide issues, for example the diversion of Canadian exports to the UK market as a result of the fall in US demand in the wake of the US housing market crash. Exchange rate movements can have a significant impact on timber prices. There are few trade barriers – apart from local political barriers such as the Russian tariff on forest produce imported from Finland. In contrast, since the early 1990s, the opening up by Russia, first, of parts of the Siberian forest (from which Japan is a major importer) and, more recently, its European forest, is likely to have a positive impact on softwood supplies on the global market for some decades.

Worldwide demand for wood products is increasing with development and with the higher comparative cost of manufactured construction materials, given the recent and expected higher energy costs. In the long-term, a country's level of growth determines

[10] Fountains plc *Forestry as an Investment* 2006

its demand for wood products. GDP, construction starts, and industrial production are the relevant statistics for predicting demand. Notable shifts in demand have appeared from China, India and Japan[11]. Counteracting this has been a reduction in demand from the USA, where housing starts have fallen off due to the slowing of the economy. The pattern of imports and exports shows a steep rise in exports from the UK since 2003, though constituting a minute share of world trade.

In Scotland in 2007, growth in demand for timber was attributed to the increased processing capacity developed there. This highlights the impact of technology and investment on the market.

Supply of UK softwood is forecast to increase over the next 15 years, peaking in the period 2017-2021 at just over 14 million cubic metres (2007-2011: 12m m3). Many of the supply factors in forestry are fixed in the medium or long-term: growing stock, growth rates, age classes and site productivity. Some elements are more flexible, such as decisions regarding management of forest resources (thinning policy, regeneration methods and spacing). Y2K forecasts of UK softwood supply, for example, were revised downwards by 11% in 2005 to take account of 'progress in addressing sustainability issues'. Decisions relating to time of harvest will be affected by current and expected prices, and by harvesting costs. The private sector becomes a slightly more significant supplier (56% in 2022-2026 from current 52% of supply), assuming no further major reduction in the FC share of the national forest.

Worldwide supply will be affected by the development of countries' policies (eg promotion of environmental benefits of forestry, of woodfuel, or of recycling) and the technology available to them, which will alter their recovery rates and productivity. Russia has recently increased its production capacity by technological investment, for example, and China has the potential to increase its own supply to meet demand.

Transport is always an issue for the movement of produce with a low value/weight ratio. Shipping costs become a major hurdle in times of rising oil prices and higher costs of imported produce may make home-produced wood more competitive. Home producers may be able to make a short-term response by adjusting thinning and harvesting programmes but, because of the extremely long timber production cycle, there could not be a sustained increase in output of good quality home-grown timber for some decades. Within the UK, accessibility of forests becomes a more important factor as production costs rise.

Hardwoods account for well over half of the world's current annual wood consumption. Whereas softwood supplies are mainly concentrated in developed countries in the northern temperate zones of Europe, Asia and North America, hardwoods are much more diverse in geographical distribution, being found in all continents, primarily in tropical regions but with significant sub-tropical and temperate presence, and in countries from the least to the most economically developed. Hardwoods are used for an extreme range of products from firewood (by far the largest use globally) to luxury furniture. Their long-run supply potential is diminishing as something like 10million hectares of predominantly hardwood forest

[11] Stuart Goodall *'Soaring Demand'* The Chartered Forester Winter 2006/7

are cleared annually in the tropics and many other areas being legally harvested lack good subsequent management.

Whereas UK softwood production has steadily increased over the last fifty years, hardwood deliveries have been declining since 1990 to less than half-a-million tonnes in 2006. Produce ranges from the very best quality butts for veneer and luxury furniture making to rubbish which is fit only for burning. There is considerable potential to increase hardwood production from existing lowland forests in the UK, half of which are currently rated as un-(or under-)managed, and good quality timber production is not necessarily incompatible with achieving multiple social goals from the same areas, but substantial investment would be needed over many decades. (See also comment under *Woodfuel* below)

Despite the inevitable uncertainties surrounding the long-term outlook for timber markets, global demand seems likely to increase as a result of further economic development. Another outcome of development, historically, is that when a country reaches a certain stage of development, more emphasis is given to conservation and timber output tends to be restricted. International environmental concerns may also lead to further reduction in large scale harvesting of tropical hardwoods in some areas, putting additional pressure on the global market. Production of good quality hardwoods is perhaps the most likely way of securing good returns to forest land in decades to come, but the net capital investment required, and the applicable discount rate, will be crucial.

Where broadleaved woodland can be brought into productive condition and managed from within current revenues, on an estate with a strong forestry tradition, aiming for high quality timber alongside recreation facilities and non-marketable outputs, may be a sound long-term strategy.

Woodfuel

The woodfuel sector is of interest because it may provide a market for what have hitherto been unvalued by-products of the timber production process. In 2007, three major wood-fired power stations opened in the UK, stimulating a 12% increase in demand for wood products. A second ‘wave’ of such power stations will open in 2009.

In March 2007 the Forestry Commission issued ‘A woodfuel strategy for England’, which aims to bring an extra 2M tonnes of wood annually to market by 2020. The strategy is an integral part of the UK government’s energy security, waste, and sustainability targets, and also contributes to the binding agreement at EU level to move towards providing 20% of heat and power from renewable sources. Overall there is a ‘positive policy environment’ for the growth of wood energy.

The woodfuel strategy is primarily targeted at under-managed woodlands, aiming to extract some of the estimated 4.2m (‘green’, ie undried) tonnes of wood product that is currently not harvested, two-thirds of it in broadleaved woods. A measure of the ambitious scale of the strategy is that 2m tonnes is four times the current total annual harvest from BL forests in UK.

The strategy is welcomed by the industry, although ConFor, the industry representative body, notes that new resources must be found to stimulate supply and demand if the market is to become established. Currently the primary difficulty is thought to be the stimulation of product into the supply chain, which is itself disjointed, and therefore it is hoped that significant incentives will be targeted at woodland owners, possibly expanding provision for management grants. Lack of knowledge and interest in woodland management on the part of the landowner is a major obstacle, as well as absence of financial incentive. Finances will depend[12] on the individual site but there 'should' be some return even at this early stage of the market. UPM-Tilhill note that it is 'clear … that wood fibre for fuel is here to stay and that investment is gathering momentum'.

The low value, bulky nature of the product means that transport costs could restrict suppliers to relatively local markets, and thus the location of large scale consumers of woodfuel will be crucial. On the other hand, developing technology could well yield viable units for Combined Heat and Power generation for residential and industrial developments of comparatively modest scale.

The emergence of significant local markets for fuelwood could be very helpful to The Crown Estate in achieving the goal of bringing some of the more 'detached' estate woodlands into fully productive condition.

Other marketable outputs

Sporting rights (shooting, stalking) are often included in the purchase of a plantation. They can provide regular income, the value of which is likely to depend on accessibility to population as well as quality of shooting. Research in English estates[13] revealed sporting values of up to £100,000 per annum.

Trees and woodlands have not only traditionally formed key elements in the landscape of most of Britain but they have also always provided a favoured backcloth to outdoor recreation – including 'sitting in the car' and 'picnicking beside the car' as well as more active pursuits from walking to orienteering, carriage-driving to golf. Opportunities for informal and extensive recreation are, by their very nature, difficult or impossible to market: the density of land use is low and control of access impracticable. Marketing opportunities relate to providing services for tourists and rural leisure seekers – overnight accommodation, car-parking, food, toilets, souvenirs and information. Some estates have successfully developed these kinds of facilities for visitors, either directly or under leasing or other franchise agreements, and thereby gained significant supplements to estate income. Such developments may generate befits for the local economy and many planning authorities are sympathetic to sensitive design solutions for buildings. Providing tourist facilities usually produces much quicker returns than most other forest-related ventures.

Non-marketable outputs

[12] Peter Whitfield, UPM-Tilhill in Forestry &Timber News June 07
[13] Nicholls & Young *Private Woods in Crisis?* 2005

Financial returns from timber products are widely recognised as being only a fragment of the real value of a region's woodlands. In the Woodland Wealth Appraisal for the East of England (2003), for example, the annual gross output, direct and indirect, from 'Timber Production and Processing' was estimated at £83,000 (12%) out of a total 'annual wealth estimate' from forestry of £680,000. 'Quality of life' and 'Environment' benefits were estimated at £242,000 (36%). More valuable than timber, in many forests, particularly in the South-East of England, are the various non-market benefits offered by woodland.

The Forestry Commission (2002) has stated that its central role is to help owners and managers to deliver environmental and social benefits as well as economic ones. It is committed to increasing the public benefits that are provided for society through the sustainable management of England's woodland. These non-market benefits include open-access non-priced recreation, landscape amenity, biodiversity, carbon sequestration, pollution absorption, water supply and quality, and protection of archaeological artefacts.

Low-level, informal recreation is the most common public use of forests, and therefore public access is a priority in current policy. Incentives and support measures are employed to encourage the increase of permissive access onto privately owned woodland. Their success has been limited (Forestry Commission 2002).

Approvals for whatever (if any) public assistance is available for private forest establishment and management will be dominated by the prospects of supply of a wide range of social benefits to an even greater extent than now.

Returns to forest investment[14]

Total return: The total return from a forest investment comprises income from harvesting of the main crop, from thinning, from non-forestry activities, and from grants or subsidies received. The main costs to set against this income are roading, harvesting, and maintenance. In addition to these flows, any increase in the capital value of the land must be considered. Market valuations are conventionally based[15] on a return on capital of around 4.0% after tax.

Natural growth: The value of a commercial forest is mainly calculated by reference to the age, quality and yield class[16] of its crop. Physical growth of trees results in assured growth of the forestry asset, and, as the trees grow, not only is there a greater volume of wood, but also it becomes more versatile – for example it can be used for sawlogs[17] rather than just wood pulp – and therefore the unit price rises.

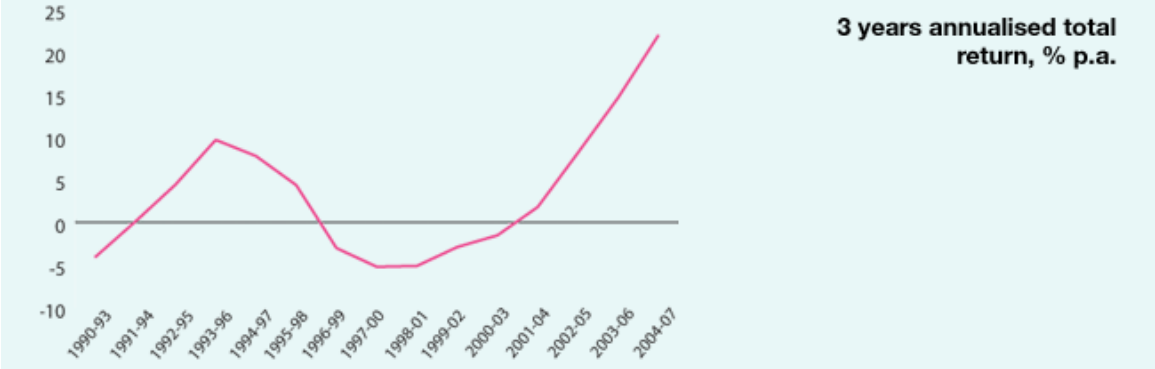
[14] Sources:
IPD *IPD UK Forestry Index (2007)*
FIM Services Ltd *UK Timber Investment 2007*
Fountains plc *Forestry as an Investment* (2006)
Telephone interview with Jason Sinden, Investment Manager, UPM-Tilhill
[15] Personal correspondence, Jason Sinden, Forestry Investment Manager, UPM-Tilhill
[16] the measurement of site productivity and crop growth rates. Takes no account of timber quality, harvesting costs, location, amenity or development opportunity.
[17] The part of the tree big enough to be sawn into logs. The most valuable part of the tree.

It is possible to quantify the likely realisable volume of timber from a plantation, of which the purchase or establishment cost as well as subsequent management costs are broadly known. This makes valuation by discounted cashflow analysis possible, but requires heroic assumptions regarding future timber prices – perhaps decades hence.

Type/location of woodland: Lowland broadleaf/mixed woodlands tend to carry amenity value and, according to UPM-Tilhill, such woods have 'nearly doubled' in value since 1999. Most of the woodland in the South-East of England is amenity woodland, involving annual net expenditure rather than yielding a net income and representing a rational investment only in terms of the 'capital value play'[18].

Upland commercial conifer plantations tend to be valued closer to their total financial return, since the major part of their value is the timber crop to be harvested from them. Nonetheless, a premium has been paid for such plantations in recent years (i.e. their value has not fallen in line with timber prices) because of lack of supply. This imbalance between demand and supply has been attributed[19] to three factors: 1) the relatively small size of the UK forestry market given the nation's population and wealth, 2) the large extent of state ownership of major forest resources, which restricts supply, and 3) an influx of investors following the boom in the financial and property sectors. This last driver has changed its direction recently, and as noted above, there is shortly to be a significant divestiture of state-owned land, but the relative balance of population and forest resource, in the UK as well as world-wide, seems a factor that could be expected to continue to support the value of woodland. Demand is expected to exceed supply in the medium and long-term.

Returns data:



In recent years, a measure of the performance of commercial forest investment has been published by Investment Property Databank (IPD). This index, while a helpful guide to movements in commercial values and returns, is based on data from a very limited and unrepresentative selection of UK forest estates, being confined to 145 forests of predominantly Sitka spruce, mostly prime plantations in upland regions. The most recent IPD UK Forestry Index shows an average total return in 2007 of 31.6% (2006: 20.6%) and a 3-year annualised total return of 22%. This compares favourably with the equities, bonds and commercial property markets; the outperformance has understandably been fêted in the media[20]. Over 15 years,

[18] Telephone interview with Crispin Golding, Investment Manager, UPM-Tilhill.
[19] Fountains plc *Forestry as an Investment* (2006)
[20] eg: http://www.ttjonline.com/story.asp?sectioncode=14&storycode=56187

however, forestry performed least well of any of these investments. Its allegedly low volatility and its low correlation with the performance of equities compensate to some extent for this low long-term return.

The range of returns between the best- and worst-performing estates (36.4% to 2.3%: range 34.1%) was wider than ever in 2007 and was significantly greater than the 9.9% range experienced at the bottom of the market in the 1990s.

The IPD Forestry Index analyses returns by age and by region. In 2007, mature plantations[21] outperformed those aged 0-10 years, which is attributable to the fact that the returns on older plantations correlate most closely with timber prices. Over 3, 5 and 15 years, however, forests aged 0-10 years performed best. Regionally, South Scotland was the best-performing region over 3 and 15 years.

Timing of returns

The pattern of cashflow will depend on the individual forest and its management. As noted above, return from a lowland broadleaf/mixed amenity woodland will be largely capital appreciation; cash is generated only on sale of the asset. Income returns will rely on the possibility for marketable recreational/amenity uses and therefore be closely related to location relative to population centres.

Upland conifer plantations can be managed to provide a flow of income; there is considerable control over the timing of harvest and if stands are of mixed age there can be a reliable supply of timber to bring to market when conditions are right. Only a large investment will be capable of being structured to produce a regular flow of income, but when this is achieved forest investment has been likened[22] to bond investment – long-term, independent of financial markets, and with a regular income.

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http://ftadviser.com/InvestmentAdviser/Investments/AssetClass/Equities/News/article/20080625/b4c64418-42bb-11dd-b26f-0015171400aa/Timber-returns-outstrip-major-asset-classes.jsp

[21] 31-40 years

[22] Mark Campanale, Henderson Global Investors, FT investment Adviser magazine (15.05.06)

4. The Scenarios

We cannot know the outcomes of these uncertainties and challenges. Rather the aim here is to explore the range of possibilities and their implications for land use options on The Crown Estate. We do this through the development of some simple scenarios. The approach adapts that taken previously in a project undertaken for the Land Use Policy Group (Hodge and Reader, 2006). As explained by Foresight (2002), scenarios are not intended to predict the future. Rather they offer a framework within which to review the future on the basis of explicit assumptions about how the various drivers and their outcomes may develop over a given period of time.

It is possible to relate scenarios to any particular sets of circumstances, either general or specific. In this context, the focus of our attention is on the land use options and the challenges and potentials for rural businesses. Thus our primary focus is on the potential financial returns to rural land and associated businesses, but we also recognise that these must be set within their wider social, economic and environmental contexts. We have already noted the very many possible drivers and potential outcomes. Thus scenario development involves a mix of rational analysis and subjective judgement in selecting appropriate approaches on which to concentrate, given the particular focus of the analysis.

Clearly, in practice these factors are interdependent and interrelated. There are no simple linear causal relationships between them and so no logical order in which they may be considered. But some aspects may seem more 'exogenous' to our focus than others. Generally, Environment, Technology and Society may be seen as external drivers, influencing the Economic opportunities and Politics.

4.1 Approach to the scenarios:

Given large numbers of drivers, all of which may operate at many different levels in different ways, it is helpful to give some structure to the discussion of future possibilities. We develop our scenarios on the basis of clusters of relevant drivers, especially relating to prospects for commodity and energy markets and changes in agricultural, forestry, water, climate, biodiversity and international trade polices. The aim in principle is to identify clusters within which the drivers show a high degree of correlation. It is necessary to keep to a small number of scenarios in order to keep the analysis tractable and in this case we develop four scenarios within a 2x2 matrix. We also believe that it is helpful for discussion if the concepts behind the scenarios are relatively simple and transparent. This implies that we have to identify two core clusters of drivers.

The two core clusters of drivers adopted here relate first to the financial returns to land use and second to the state of government policies, primarily towards the environment and the attitudes amongst voters and consumers, which we assume in turn influences policies. The scenarios inevitably are designed to represent extreme sets of circumstances as a basis for a structured discussion. However, in practice we anticipate that the future outcomes are likely to lie somewhere within the space mapped out by these four scenarios.

Financial returns to land use

The first set of drivers determine the financial returns associated with land management, i.e. the market prices received for the outputs and paid for the inputs associated with alternative land uses. A substantial range of drivers have their major influence on the levels of commodity and energy prices which will determine the revenues that can be generated from commercial land uses. This includes factors associated with both demand and supply: the drivers of population and economic growth that determine aggregate demand for land use products and the capacity of economic and natural systems to supply them. Climate change will have impacts on prices both through instability that it causes in weather patterns and through longer term changes in the production potentials of different regions. Higher prices may also be associated with global security or disease risks. The costs of production will be influenced by raw material costs, the costs of manufactured inputs and the costs of labour. Input costs are probably more predictable, although again, energy prices will be a key factor introducing uncertainty as to the price levels faced for a range of inputs.

These factors will determine the returns to alternative land uses and land managers decisions as to how to use the land and will determine asset prices, especially land prices. The returns thus flow through to other land use sectors, even where the commodities are not generally traded internationally, including livestock and biofuels. Market forces will thus tend to generate some degree of correlation amongst prices and returns giving greater justification for treating financial returns as a single cluster of drivers. The level of prices in the UK is most likely to reflect the levels operating on world markets, especially so given the decoupling or agricultural policy support measures. It is possible that some degree of domestic price protection could be re-introduced that has the effect of insulating domestic prices from world prices but we believe that this seems less likely in the context of the process of liberalisation in markets that has been underway over the past twenty years. There may of course be many other types of government intervention and this is the focus of the second cluster of drivers.

If returns to agricultural activities increase, more land (resources) will be brought into that productive activity, thus increasing the supply, and so reducing returns. It is thus unlikely that any one scenario will drive profitability very far without compensatory effects on (and from) other sectors. This process of compensatory effects serves to keep all resources in the uses that are most productive in terms of meeting the preferences of the population.

Government environment policies and public attitudes

Within a democracy, we assume that attitudes towards the role of government and the nature of government policies are interrelated. The focus here is particularly on the environment and attitudes towards the environment will influence both the way in which governments respond to environmental issues and the actions of consumers with regard to decisions about their food and energy purchases. We assume that under ‘pro-environmental’ attitudes, governments will be willing to be more interventionist and be motivated to adopt more ambitious environmental targets and

take actions in order to achieve them, even if this risks slowing economic growth and imposing costs on producers, taxpayers and consumers.

With our present focus, the emphasis is primarily on policies that will impact on the options and constraints that affect land uses

Policy towards climate change will be a significant element of any government's environmental policies in the future, with the objectives both of mitigating future climate change and promoting adaptation to the inescapable levels of climate change that cannot be avoided. But the extent and vigour of government policies remains to be seen. This cluster of drivers relates particularly to governments willingness to impose limits, constraints and incentives on land managers in order to advance environmental and related public objectives. The Climate Change Bill currently before Parliament sets ambitious targets for the mitigation of GHG emissions, but the targets are some way into the future and the degree of commitment of government to impose changes that cause significant costs on producers and consumers remains to be seen. We assume that a 'pro-environment' government will take more vigorous actions in order to limit GHG emissions and to promote adaptation to climate change. This may take the form of tighter regulation, environmental taxes or trading schemes or greater incentives to change behaviour.

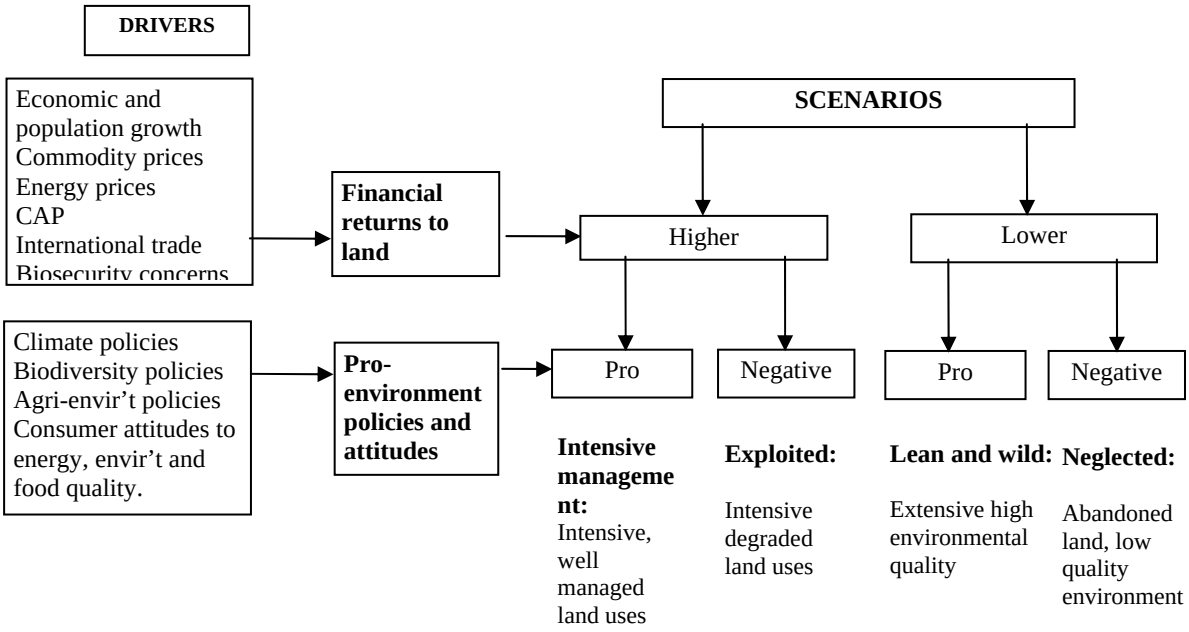
A 'pro-environment' would also be expected to maintain an active agri-environment programme that supports environmentally sensitive agricultural land uses, either by maintaining them where land might otherwise be abandoned or by restricting intensity where the high level of intensity could be environmentally harmful. It may also be assumed that the general public will have higher expectations for the standards of land management and that these may be incorporated into stricter conditions and regulations.

We also anticipate that a 'pro-environment' government will generally take a more interventionist approaches towards other areas of policy, such as spatial planning and policy. The planning system could be more restrictive, demanding higher standards for new developments and spatial policy might do more to redistribute economic activity away from congested areas towards areas with lower levels of economic activity.

Pro-environmental attitudes are also expected to reflect consumer behaviour in using consumer choices to advance environmental objectives. This would relate to the selection of products and adoption of behaviours that cause lower levels of environmental harm. We anticipate that this would be associated with an increased demand for higher quality food products perhaps sourced on a local or niche basis, successful operation of assurance schemes, demand for green energy and demand for products associated with environmentally related activities, such as outdoor recreation and rural tourism.

A third element of pro-environmental behaviour would be revealed in terms of support for conservation organisations that own and manage land with conservation objectives and through contributions to local environmental funds that can allocate funds for environmental and land management projects.

Figure 4.1: Scenarios and Their Drivers



4.2 The characteristics and implications of the scenarios

Limitations of scenarios

As we have indicated, in practice the multiple drivers identified as potential influences are more likely to pull in different directions leading to more complex but probably less extreme outcomes. There is no necessary direct correlation between global energy and global food prices. And the prices received by farmers in the UK are also subject to exchange rates and government intervention. Similarly there may be circumstances where public preferences are favourable towards the environment, but where public policy is not. This would place a greater emphasis on market and voluntary initiatives. Thus the policies that are operated may be better oriented towards seeking to direct private actions towards socially valued outcomes rather than adopting the more direct forms of government action that have tended to predominate in agri-environmental policy to date.

We may now summarise some of the characteristics and implications of these four scenarios (see Figure 4.1).

Intensive management
In the 'intensive management' scenario financial returns to land are relatively high implying higher potential farm incomes and agricultural rents. This assume that increases in output prices more than counter the increase in input costs that are likely to be associated with the higher output prices. In these circumstances, land managers face an incentive to intensify their agricultural production, but this is likely to conflict with pro-environmental attitudes and government policies.

A critical issue will be the way in which government policies are developed, either treating the impacts of agricultural production as pollution and hence imposing strict regulations over agricultural practices, or else treating environmental quality as a public good implying that farmers will be paid in order to provide an higher environmental standard. In practice, and as reflected in current policies, there will be some mix of these two approaches. In recent years we have seen the introduction of positive payments for agri-environment schemes but with a rising 'reference level' that defines the standard of environmental management that is required as a 'duty' of land management before payments for higher standards can be justified. This approach will influence, for instance, whether the current cross-compliance standards are simply incorporated into legal requirements as the leverage associated with declining values of the Single Farm Payment reduce the leverage available to government to enforce them. Similarly, assuming that significant changes are required to agricultural practices in order to meet the requirements set out in the Water Framework Directive, the question will arise as to whether these are to be met by means of stricter regulations or by voluntary action and positive incentives. There would seem to be little basis on which to judge which route is more likely to betaken beyond the experience to date that policy has been by means of a mix of the two approaches.

The same arguments will apply in the debate about the changes in agricultural systems required in order to meet the likely reductions demanded in GHG emissions. If past experience to this is a guide, we may anticipate that the initial changes will be encouraged by means of voluntary adaptation and positive incentives but that once the environmental standards come to be regarded as 'normal' the policy approach will become more regulatory. This suggests initial policy approaches may be introduced through the existing agri-environment programme whereby land managers can be subsidised for introducing innovations and changes to their systems that mitigate GHG emissions. In the longer term, given that the requirement to reduce emissions will continue indefinitely, the necessary incentives may be transferred onto more specific trading schemes or built into legal regulations. In fact, some mix of these would seem most likely.

However, we cannot assume that because government adopts a pro-environmental policy stance there will be generous environmental payments. In fact, because of the relative profitability of agricultural production activities in this scenario, the opportunity cost, or the income foregone from reducing production intensity or placing land into conservation uses is also relatively high. This implies that conservation activity could need to be more highly targeted by government policies on higher priority, more critical areas for conservation.

The pro-environment consumer attitudes imply that there will be opportunities to gain a price premium by marketing higher quality and environmentally friendly products.

Tenants will thus face a wider range of business options but will also be challenged to meet higher environmental standards.

Exploited

Under the 'exploited' scenario, financial returns to land uses are high, but without strong pro-environmental attitudes or government policies. We again assume that the

higher level of output prices outweighs any increase in input costs. This presents farmers with a high degree of market choice as to how to manage their land with relatively few regulatory constraints or environmental incentives. Farmers have a strong incentive to intensify their production activities without significant countervailing actions by government or consumers to restrain the impacts on the environment. This position would in some respects be similar to that in the 1970s and early 1980s when production incentives, in that case driven by government commodity market price support measures, led to significant environmental losses. Even in the absence of agricultural commodity support programmes, government might still provide incentives for more intensive production through schemes to promote food and energy security, perhaps supporting the production of biofuels. But the general philosophy of government is to let the market solve potential supply problems.

The extent of land use conservation activity within the rural environment in these circumstances would then tend to depend to a great extent on the security of the conservation measures introduced in previous time periods. Given that most agri-environment schemes permit landholders to opt out at the end of a set contract, it is likely that much of this protection will be lost once farmers recognise the long term nature of higher prices and respond to it.

Weak consumer attitudes and preferences towards the environment also mean that there are limited opportunities for linking environmental conservation to market opportunities. The primary incentives facing farmers will relate to the financial returns available from commodity production. They may have personal preferences for environmental conservation, and the relatively high returns would allow some farmers to pursuer this approach, but it will generally not be supported by community pressures or social norms.

Lean and wild

Despite the present concerns as to the impacts of high global commodity prices, the possibility remains that in a few years' time we may revert to the longer term decline in the levels of commodity prices and lower returns to agricultural land. In these circumstances attention returns to how to minimise agricultural production costs, how the resources available to the farming businesses may be organised in order to maximise returns, and whether resources may achieve a higher return in alternative uses.

The direction of change for farm businesses would be likely towards simpler, lower input, probably larger scale agricultural systems. This would be exacerbated should inputs costs, especially energy prices, remain relatively high. This may well be likely in a world in which we have passed 'peak oil' production levels, economic growth continues in China and India, and there are pressures to maintain high energy prices or equivalent polices, in order to deter carbon emissions.

The presence of pro-environmental attitudes and government policies may offer some opportunities. This scenario does offer the prospect of some environmental advantages, such as reduced emissions of minerals or pesticides from agricultural production, but the lack of management would also have detrimental effects in terms of landscape and biodiversity. This would promote more extensive land uses and,

depending on government responses, the potential for land to be abandoned. In this context, it is the lack of agricultural management that represents the primary threat to conservation and landscape values. The lack of management is most likely to arise in the uplands, but could also affect lowland areas too, especially with regard to problems of undergrazing.

Thus we may anticipate agri-environment schemes that promote a continuation of relatively low intensity agricultural systems. With relatively low returns to agricultural production, the opportunity costs of conservation activities would be low with the implication that an agri-environment policy with a given level of funds available could influence land uses across a relatively large area. We might then envisage ambitious schemes to reorient large areas of land towards conservation uses.

The pro-environment consumer attitudes will generate some commercial opportunities for products and farm activities.

Land would be relatively cheap and there could be opportunities for managers of particularly efficient farming operations to expand the scale of their operations, but to a lesser extent than would be the case in the fourth 'neglected' scenario.

Neglected
With low financial returns and without any active agri-environmental policy, land would be commonly unmanaged in way not seen since the 1930s. There would inevitably be calls for a resumption of protection for farming, but perhaps in the context of a long run decline in the political importance attached to agriculture these may not be politically attractive.

In these circumstances, without even a lifeline of support for land use through agri-environment schemes, we may expect substantial extensification of all types of agricultural system as well as land abandonment.

Agricultural land prices would be low and so there could be some more positive intervention by private individuals and conservation organisations, even if this did not represent a general public pro-environmental attitudes, who may be attracted to acquire land to be managed for environmental values. The extent of such activity in the absence of strong government environmental policy clearly depends on attitudes towards the rural environment and the willingness of individuals to allocate their own resources towards it, either individually or collectively through non-profit organisations.

What government policies that are directed towards the conservation of the rural environment would be targeted on critical conservation values are most threatened by neglect and abandonment and of less immediate attraction to the general public. But even here, we may anticipate that government would tend to adopt a regulatory approach rather than positive payments.

5. Implications of the scenarios for The Crown Estate

5.1 Climate mitigation and adaptation

General implications for The Crown Estate

The projected climate impacts described above have the potential to affect agriculture in the UK, and The Crown Estate, both negatively and in some cases positively. An extended growing season in some areas, together with elevated CO_2 levels may increase yield. On the other hand, extreme events such as droughts or flooding, have the potential to seriously affect production, depending on what time of the growing season they occur in. Box 5.1 describes the impact of the 2003 heatwave on agriculture in the EU. Summers of the type experienced in 2003 are expected to occur once every two years by the 2040s, and by the end of this century, would be classed as a "cold" summer Stott *et al*.. (2004).

Box 5.1: the effect of the 2003 heat wave on agriculture

The 2003 heatwave: the effect on agriculture

Europe experienced a particularly extreme summer in 2003, with temperatures up to 6˚C above long term means, and precipitation deficits of up to 300mm. The extreme weather decreased the quantity and quality of agricultural harvests, particularly in Central and Southern Europe, affecting a large proportion of harvests and increasing production costs (UNEP, 2004). Cereal production in the EU was more than 23 million tonnes lower than in 2002. The most damaged arable crops were wheat and maize. Livestock farmers were reported to suffer the most because of a lack of green fodder in the following winter and higher compound feed prices (UNEP, 2004).

Ciais *et al*.. (2005) report reductions in gross primary productivity, coinciding with reduced evapotranspiration and soil drying due to the rainfall deficit. More frequent extreme droughts may counteract the effects of the anticipated mean warming and lengthening of the growing season, negatively effect the health and productivity of ecosystems, reversing sinks to sources, and contribute to positive carbon-climate feedbacks .

COPA-COGECA (2003) estimate the global financial impact of the 2003 drought, including the impact of forest fires at €13 billion. Additional anticipated effects were problems of soil erosion and flood, as well as effects on the winter sowing and budding of trees. Changes in yield of this magnitude in Europe have impacts all over the world, with world prices for grain and wheat increasing due to the shortfall (Brown, 2003).

The Crown Estate will be affected as part of UK agriculture as a whole. Specific areas that may be of particular concern would be areas of the south east which may face water stress in the future and coastal areas which may be at risk from sea-level rise or erosion.

1. Types of systems that may be promoted by government

Climate resilient

Because of historical emissions and inertia in the climate system, the world is already committed to a certain degree of climate change, regardless of how much emission reduction occurs from now on. Therefore, agriculture must prepare itself as best it can in order to cope with the effects of climate change (known in climate change literature as "adaptation"). Adaptation to climate change is being taken seriously at all levels, as indicated by various initiatives, including the EU Commission who have published a Green Paper on "Adapting to Climate Change in Europe: Options for EU action" and will be publishing a White Paper on the same topic later in 2008; the UK Royal Commission on Environmental Pollution who are due to produce a report in 2009 on "Adapting the UK to climate change". The UK government has introduced an "Adapting to Climate Change" cross-Government programme, as well as UKCIP (UK Climate Impacts Programme), which aims to help organisations adapt to inevitable climate change, and there are a number of recent calls from agencies such as Defra commissioning research into adaptation, across all sectors but certainly including agriculture. As such, a part of the government's climate change plan is very likely to focus on promoting "climate resilient" systems. Building the adaptive capacity of the agricultural sector to minimise the impacts of a changing climate is likely to be a core aim of future policy, however this is also in the best interest of the agricultural sector, and The Crown Estate, itself.

Low carbon

The UK is committed to reducing greenhouse gas emissions, with both international reduction targets under the Kyoto Protocol, and voluntary national targets. Under the Kyoto Protocol, the UK is committed to reducing emissions by 12.5 percent below 1990 levels by the period 2008 - 2012, and is currently on track to have reduced them by 23.6 percent below 1990 levels by 2010 (Defra, 2008). Nationally, the UK has set even higher targets, with the Energy White Paper in 2003 adopting a longer term goal to put the UK on path to reduce emissions by 60% by 2050, with real progress by 2020. At present agriculture has not been a target for emission reductions and has no reduction commitments as a sector. However this may change over the coming decades and there are likely to be policy-incentives within the CAP to encourage emission reduction in agriculture. Consumer pressure for low-energy produce may also increase, and consumers may pay a premium for low-energy produce.

2. Implications of the scenarios for The Crown Estate

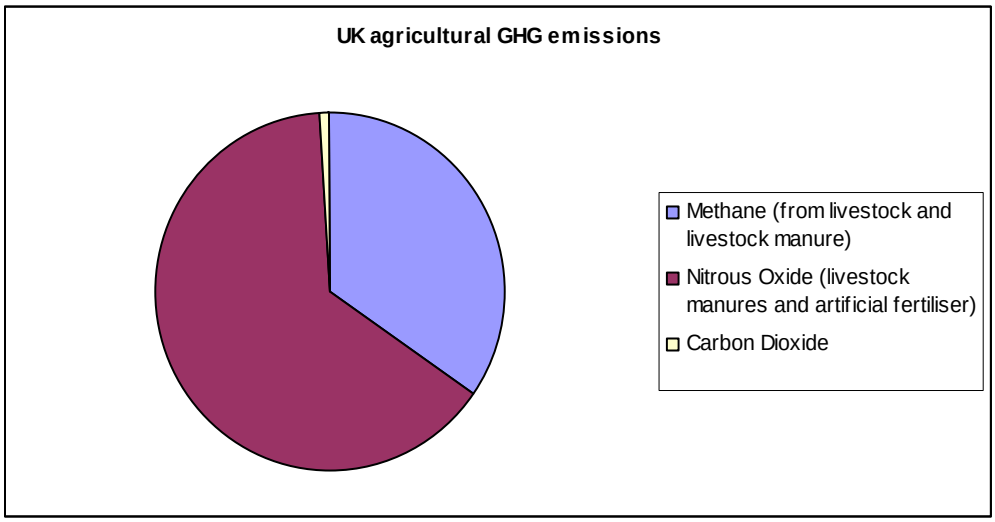
How would The Crown Estate achieve a 60 – 80% reduction in GHG emissions by 2050?

Reducing GHG emissions from agriculture by any meaningful amount is notoriously difficult to do without affecting production. Agricultural production produces two main GHGs, methane and nitrous oxide (excluding emissions of carbon dioxide (CO_2)

involved in energy use). Methane is produced predominantly by ruminant livestock, while nitrous oxide is produced through soil processes and manure management and fertiliser application. Methane has a global warming potential (GWP) of 21, meaning that one kilogram of methane is 21 times more effective at trapping heat over 100 years than one kilogram of CO_2, while nitrous oxide has a GWP of 310.

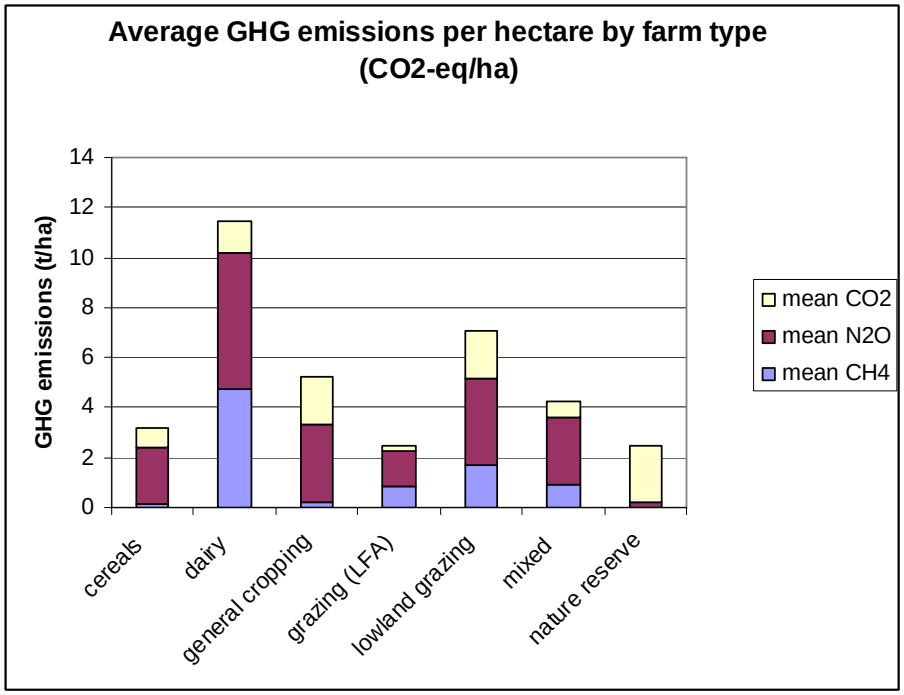
UK agriculture as a whole produces seven percent of total UK emissions. Within this, in 2006, 36 percent was methane, 67 percent nitrous oxide, and 1 percent carbon dioxide (illustrated in Figure 5.1) . Emissions in 2006 were 18 percent below the 1990 levels, which has been achieved mostly through a reduction in animal numbers following structural changes.

Figure 5.1: UK agricultural emissions (2006)



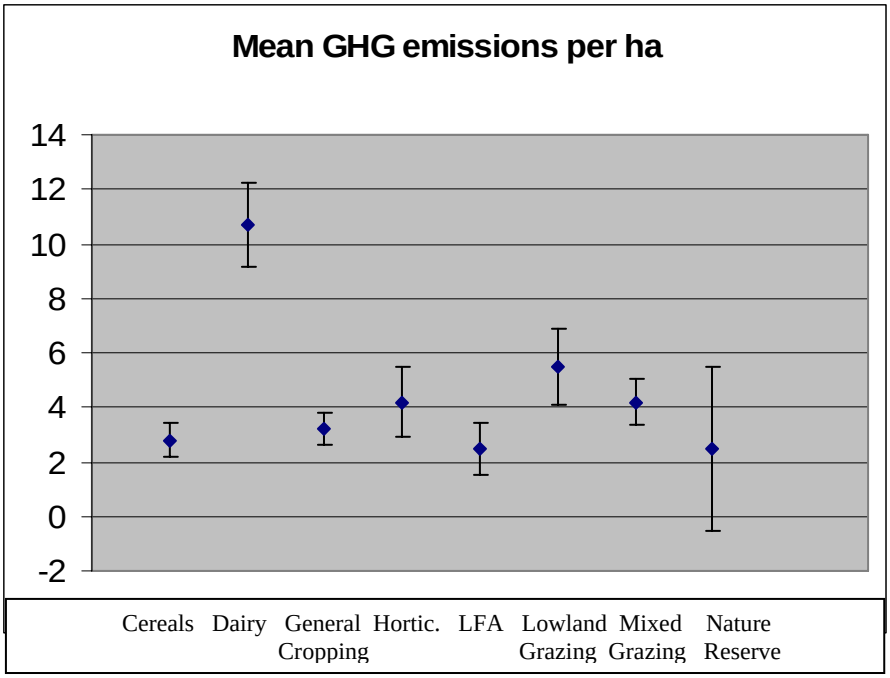
A recent study from Natural England (Natural England, 2008) evaluates greenhouse gas emissions from farms and farm types in the UK. The aim of this project was to improve the awareness among the farmers involved of the importance of agricultural greenhouse gases, and possible actions to reduce these emissions, as well as estimate greenhouse gas information on individual farms and farm types. Figure 5.2 illustrates the average emissions of methane, nitrous oxide and carbon dioxide, per hectare for main farm types from this study. The data in the study are very close to the UK National Greenhouse Gas Inventory.

Figure 5.2: Average GHG emissions per hectare by farm type, in CO_2 equivalents (Natural England, 2008)



This figure illustrates that dairy production produces the most GHG emissions, with relatively similar amounts of methane and nitrous oxide. Lowland grazing systems also produce relatively large quantities of GHGs. These are largely due to the emissions produced from ruminant animals. Grazing on Less Favoured Areas (LFA) produces relatively little emissions per hectare, primarily because of the low stocking rate. Arable farming does not contribute as substantially as livestock systems do towards emissions. There are however considerable variations amongst farms within farm types as illustrated in Figure 5.3.

Figure 5.3: Mean Green House Gas Emissions for Different Farm Types



It is notable that, even though there are clear differences between some of the farm types, there are also there are considerable variations within them. Thus, for instance, significant variations within Horticulture were between glasshouse production and outdoor market gardening. For copping farms, there were considerable differences depending on soil types, with emissions from peat soils being significantly higher. This suggests that emissions reductions policies cannot simply be incentivised by farm type, it will be necessary to take account of more specific circumstances.

A recent Cabinet Office report (The Strategy Unit, 2008, p81) identifies three key problems in 'de-carbonising' global farming:

- The release of carbon from soils and from vegetation when land use changes, such as where forests are cleared for agriculture;
- The nitrous oxide emissions associated with fertiliser use and livestock manure; and
- The methane produced by livestock, in a period when demand for meat and diary products is expected to soar.

Much of the focus of the current debate about climate change mitigation has been on carbon, but much of the GHG emissions from food production arise in the form of N_2O and CH_4 on which there has been much less research. The Strategy Unit report concludes that agriculture is set to have a more prominent place in GHG abatement strategies in the future (p83).

A study by the Scottish Agricultural College (Topp and Rees, 2008) of the carbon footprint of a mixed farm in the north of Scotland suggest options for reducing the footprint involving both reducing emissions and maximising carbon uptake (Table 5.1).

Table 5.1 Options for Reducing the Carbon Footprint

Large reductions (40-80%) could be achieved by:	Smaller improvement (20-40%) would be possible by:
Planting more trees Reducing animal stocking rates Reducing fertiliser N application rates	Altering animal diet/breeds Increasing N uptake efficiency Improved manure management Improved cultivation practices (minimum tillage, one-pass)

The three main options for reducing **methane** (CH_4) emissions from livestock production are:

1. Reducing livestock numbers
2. Increasing efficiency of livestock production: improving efficiency of animal performance will generally lead to a reduction in of CH_4 emitted per unit of animal product. This can be achieved through better quality of feed as well as increased feed intake.
3. Modifying rumen digestion: Either through the use of rumen additives or modifying the rumen bacterial population, which can then contribute to (2) by increasing the efficiency of livestock production.

Essentially methane emissions from livestock are very difficult to reduce substantially without reducing animal numbers or capping production (O'Hara *et al.*, 2003). The most promising strategy is to reduce methane emissions per unit of output.

The primary method of reducing agricultural **nitrous oxide** (N_2O) emissions is through changes in farm management. Table 5.2 summarises the main management options for influencing N_2O emissions from agriculture. Agricultural management has a major influence on nitrogen availability and environmental conditions, through for example, fertiliser applications, livestock waste handling, residue management or operations affecting the structure, aeration and pH of soils (AEA Technology Environment 1998). On average, only 10.5 percent of the N in grass, silage, or other feedstuff is converted by grazing animals into milk, meat, eggs or wool, and the remainder is excreted in dung and urine (O'Hara *et al.* 2003). Mitigation options should focus on limiting the *direct* loss of N from animal excreta and synthetic fertilisers, and the *indirect* loss caused by leaching, run-off and ammonia volatilisation.

Table 5.2: Main agricultural management options influencing N_2O emissions (AEA Technology Environment 1998)

Type of Option	Management Option
1. Crop Management	a)change in fertiliser application rates
	b) precision agriculture
	c) crop selection (with different N requirements
	d)breeding N-fixing crops
	e)breeding crops to improve N-use efficiency
	f)cultivation of unmanaged land (i.e histosols)
	g) irrigation management
	h) soil pH management
	i) crop residue burning
	j) reduce soil compaction
2. Fertiliser efficiency management	a) nitrification inhibitors
	b) release rates
	c) improved fertiliser placement and timing
3. Manure management	a) storage times and conditions
	b) application placement
	c) application timing
	d) application amounts
	e) export of manure (from the agricultural system)
4. Reducing the amount of manure-N	a) dietary manipulation
	b) breeding N-efficient livestock
	c) livestock selection (eg types, herd sizes)

These changes in farm management can be achieved through policies such as financial incentives and intervention, the imposition of regulations, and education and extension (AEA Technology Environment, 1998). While many of these strategies involve changes in management and more efficient and strategic use of fertiliser,

others may affect production itself, particularly in relation to livestock production. While animal numbers may decline in any case due to policy reform, reducing animal numbers solely in response to GHG mitigation aims is unlikely to be a realistic action (although it would achieve the greatest reductions).

A recent study by NERA (2007) provides estimates of the reduction potential of various mitigation options as well as the marginal cost of this abatement. The options considered feasible and acceptable to the market are summarised in Table 5.3, others were provided but were considered either unacceptable to the market, such as vaccination to reduce methane emissions, or unlikely to be taken up, such as introducing a high fat diet to reduce methane emissions.

Table 5.3: Summary of feasible and acceptable abatement measures (adapted from (NERA, 2007))

Abatement option **Methane**	**Total reduction potential (%)**	**Cost of additional abatement (£/tCO2-e)**	**Comment**
Reduced enteric fermentation			
Improved fertility management	7	66	
Improved milk yield by 30%	24	19	
On-farm anaerobic digestion			
Anaerobic digestion	90	172-449 depending on animal type	Cost is for methane avoided only; changes in electricity, heat not included
Centralised anaerobic digestion	14	16-41	
Nitrous Oxide			
Reduce N fertiliser	55	109	
Reduce stocking rates by 25%	25	24-205 depending on animal type	Reductions likely to be offset by other countries
Slurry application timing	2-10		

That study found that the largest opportunity to reduce emissions in the UK's agricultural sector would be to shift agricultural production away from ruminant livestock. However unless global demand for livestock products also fell, while this would lead to a reduction in UK agricultural emissions, the difference is likely to be taken up by other countries and thus global methane emissions would not be reduced. The report does also conclude that there are limited opportunities to reduce emissions within the agricultural sector at a reasonable cost per tonne of CO_2. They suggest a voluntary project or credit-based approach to reducing emissions may be an appropriate starting point for any mandatory emissions reduction scheme, and could lead to some emissions reductions as well as provide additional income to farmers through the sale of credits.

An alternative or complementary action would be rather than focus on reducing agricultural emissions directly, to increase the amount of Carbon that is sequestered in the sector, through the planting of trees and management of peat soils etc.

How will The Crown Estate adapt to the changing climate?

The main principles of adaptation are:

- **Reducing the sensitivity** of the affected system, which occurs by, for example, investment in flood defences or increased reservoir storage capacity, planting hardier crops that can withstand more climate variability, or ensuring that infrastructure in flood prone areas are constructed to allow flooding.
- **Altering the exposure** of a system to the effects of climate change, which can be achieved, for example, by investing in hazard preparedness and early warning such as seasonal forecasts and other anticipatory actions.
- **Increasing the resilience** of social and ecological systems, which can be achieved through generic actions which aim to conserve resources, but also include specific measures to enable specific populations to recover from loss (Tompkins & Adger, 2005).

Whether adaptation actions and investments are made by private or public actors is an important issue as it represents real trade-offs in policy. Governments in Europe, for example, continue to intervene in agricultural markets to reach public policy objectives of conservation, food security and farming and rural sector income support through the Common Agricultural Policy, even though the benefits may actually accrue to capital values in land. But there may be less willingness to invest in climate change responses if all the benefits are perceived to be 'private' – i.e. accrue to individual farmers, insurance companies or emerging weather futures markets. The mix of private and public good climate change impacts is the landscape against which government responses and investment priorities are determined.

The major actions for adaptation in agriculture are summarised in Table 5.4 distinguishing between technological development (which can be induced by both public and private investment); technological adoption; government programmes and insurance; and farm-level financial management. This classification was developed by examining options in arable farming regions in Canada where farmers have a high awareness of potential impacts from climate change (Smit and Skinner, 2002). Each of the categories and types of adaptation are presently undertaken to some extent and most are broadly applicable to the UK and The Crown Estate.

Table 5.4: Types and examples of adaptation options at different levels in agriculture

Adaptation	Examples	Implementation
Technological development	Crop development	Public and private investment in new crop varieties and hybrids to increase tolerance to water and heat stress or other relevant adverse conditions
	Weather and climate information systems	Public and private investments in monthly and seasonal forecasting, and early warning systems

Adaptation	Examples	Implementation
	Resource management innovations	Public and private investment in water management innovations to address moisture deficiencies and risk of drought and changing seasonality of precipitation
Technological adoption	Farm production innovations	Diversification of crop types and varieties including crop substitution. Diversifying livestock types and breeds and changing seasonality of feedlot practices
	Land use changes	Changing location of crop and livestock production and fallow rotations to address economic risks associated with climate change
	Irrigation	Implement on-farm irrigation practices to avoid recurrent drought risk
	Timing of operations	Changing timing of operations to address changing duration of growing seasons and associated changes in temperature and moisture
Government programmes and insurance	Agricultural subsidy and support programmes	Modification of crop insurance programmes to influence farm-level risk management strategies.
		Changes in ad hoc compensation and assistance for extreme events and disasters (e.g. animal diseases).
		Modify support and incentive programmes to influence farm-management practices.
	Private insurance	Encouragement of markets for private insurance of production, infrastructure and income
	Complementary resource management programmes	Development of public policies for water resource conservation and complementary conservation objectives.
Farm financial management	Private crop insurance	Uptake of private (or publicly encouraged) crop insurance or income insurance
	Crop shares and futures	
	Income stabilisation and diversification	Diversification of household income to include less weather-sensitive options.

Adapted from Smit and Skinner (2002)

There appear to be very few, if any, adaptations that have been undertaken solely in response to expected climate change. This is in clear contrast to reported mitigation actions such as investment in biofuels as a contribution to renewable energy. This result is common throughout the world. In Canada, most individual farmers respond primarily to extreme events such as prolonged drought and unseasonal or excessive rainfall. In a survey in Ontario, 80 percent of respondent farmers judged extreme events to be the most significant impact to which adaptation was required, rather than changing growing season length or heat stress (Smit *et al.*., 1996).

Table 5.5 lists some of the main climate change impacts affecting agriculture, the consequences of these for agricultural production, and possible adaptation measures. This table is based on one produced in AEA Energy and Environment (2007).

Table 5.5: Main impacts of climate change affecting agriculture, the consequences for agricultural production, and possible adaptation measures

Climate change impact	**Increased risk of drought and water scarcity** (due to decreased annual or seasonal precipitation; increase in the frequency of extreme conditions)
Consequences for agricultural production	
Conflicts among users	Shift crops from drought-sensitive areas
	Set clear water use priorities
	Increase water use efficiency
Reduced water supply	Increase rainfall collection capacity
	Improve field drainage and absorption capacity
	Reduce run-off through contoured hedgerows and buffers
	Introduce forage crops into arable rotations
	introduce more drought-tolerant crops
	Woodland planting
	Use of precision agriculture techniques
	Water management practices
	Water charging/tradeable permits
	Insurance
Climate change impact	**Increased irrigation requirements** (due to increased average and extreme temperatures; increase of drought and heat stress frequency; decreased precipitation)
Consequences for agricultural production	
Water availability decrease Water shortage in irrigated areas	Technical improvements in irrigation equipment and ability to collect rainwater
	Trickle irrigation
	Irrigation during the night
	Separation of clean and dirty water
	Installation of small-scale water reservoirs on farmland
Climate change impact	**Soil erosion, desertification, salinisation** (due to increased temperature; sea level rise; decreased precipitation; extreme conditions; melting of permafrost soils)
Consequences for agricultural production	
Desertification due to water resources deficit, loss of soil structure, land abandonment	Livelihood diversification
	Strengthen local capacity to reduce sensitivity
	Intensify research and training
Soil salinisation increases	Change in cropping

	Allocate fields prone to flooding from sea-level rise as set-aside
Erosion and accretion increase	Change fallow and mulching practices to retain moisture and organic matter
	Use intercropping to maximise use of moisture
Water logging increases	Invest in machinery or development and disseminate good practices that minimise the adverse effects of water logging
Climate change impact	**Deterioration of conditions for livestock production** (due increase heat stress; new pests and diseases; change of optimal crop areas)
Consequences for agricultural production	
Changes in livestock health and productivity	Introduction of more heat tolerant breeds
	Move herds from waterlogged fields
	Increase shelter for animals, including from heat
	Change breeding and shearing patterns for sheep production
	Supplemental feeding
Loss in forage quantity and quality	Balance of grazing and cutting
	Changes in grazing regime
	Increased use of legumes
	Change of seed mixture
	Changing time of operations
	Adjust stocking density
Climate change impact	**Sea-level rise**
Consequences for agricultural production	
Sea level intrusion in coastal agricultural areas and salination of water supply	Hard defences
	Alternative drainage systems
	Set-aside of land for buffer zones
	Alternative crops
	Livelihood diversification
Climate change impact	**Decreased crop productivity** (due to changes in monthly precipitation distribution; increased temperatures in critical periods; loss of soil water retention capacity
Consequences for agricultural production	
Crop productivity decrease	Change in crops and cropping patterns
	Industry research
	Increased inputs to maintain yields
	Irrigation
	Advisory services for farmers
Crop productivity variability	Agricultural insurance
	Crop planting diversification
Land abandonment	Design of regional adaptation plans

	Livelihood diversification
Climate change impact	**Increased risk of agricultural pests, diseases and weeds** (due to increased water logging; increased average temperature)
Consequences for agricultural production	
Pest populations and distributions increase	Use of pest-resistant varieties
	Use of thermostats and rapid-cooling to reduce pest and disease infestation
	Develop sustainable integrated pesticides strategy
	Use of natural predators
	Vaccination
	Monitoring of pests and disease patterns to prevent damages
Pollution by increased use of pesticides	Develop sustainable integrated pesticides strategy
	Advisory service for farmers
Climate change impact	**Crop quality decrease** (due to heat stress; changes in annual and seasonal precipitation distribution)
Consequences for agricultural production	
Crop quality reduction in fruits and vegetables Damage to grain formation due to heat stress	Thermal screens
	Temperature control
	Use of thermostats and rapid cooling
Climate change impact	**Increased risk of floods** (due to increase in extreme events frequency; loss of soil water retention capacity)
Consequences for agricultural production	
Increased expenditure in emergency and remediation actions	Develop contingency plans
	Create/restore wetlands
	Enhance flood plain management
	Hard defences
Flash flood frequency and intensity increase	Increase rainfall interception capacity
	Move towards farmers as "custodians" of floodplain lands with appropriate compensation
	Reduce grazing pressures to protect against soil erosion from flash flooding
Flooding and storm damage increase	Increase rainfall interception capacity/soil management
	Contour ploughing
	Increase drainage
	Addition of organic matter into clay soils
	Insurance for farm infrastructure
Climate change impact	**Crop area changes due to decrease in optimal farming conditions** (due to changes in monthly precipitation distribution; increased temperatures in critical periods; increased erosion; loss of soil water retention capacity)
Consequences for agricultural production	

Optimal conditions altered resulting in increased risk to rural incomes	Livelihood diversification
	Strengthen local capacity to reduce sensitivity
	Conversion of ambient storage to refrigerated stores
	Irrigation
	Changing cultivation practices
	Additional weed/pest control
	Movement of crops to more favourable areas
	Change of cropping mix
	Switch to alternative crops
	Increase in crop breeding investment
Loss of indigenous species	Climate change resilient crops
	Insurance
Soil deterioration due to land use changes	Extensification: enhance carbon management and zero tillage
	Precision agriculture
Land abandonment due to very large changes in optimal conditions	Intensify research efforts and training
	Livelihood diversification

In many cases, producers in the UK can learn from practices in other countries where the current climate resembles some of the changes expected for the UK, such as southern Europe, Australia or New Zealand.

Previous examples of weather variability, such as droughts, heat waves and floods, may also be used as analogues for future climate changes. As mentioned, extreme weather events are likely to occur more frequently under climate change, and if lessons can be learned from previous events, producers may be more able to minimise the damage from future events.

Historically, producers have adapted to drought by installing irrigation systems and altering the timing of harvesting and area of production, and the type of production. Following the drought in 1975, potato producers responded by increasing the area planted so that although yield in 1976 was reduced, the volume produced was higher (Morren, 1980). This drought caused serious losses in yield which have not been repeated since. This is likely to be due to several factors, including institutional learning, improved technology, and increased awareness and practical strategies among producers to cope with drought.

However there are many drivers for adaptation, many of which are not directly related to climate change. A study by Tompkins et al. (2005) found that the main drivers of adaptation in the rural land use sector were: (see next page)

- Sustainable development sparked by foot and mouth disaster
- Biodiversity and conservation
- Regulations such as the EU Habitats Directive
- Water shortages
- Crop yields and quality benefits
- Water saving
- Soil conservation
- Opportunities, e.g., the move to robust energy crops, mitigation opportunities
- Financial, costs of production, integrated farm management
- Sustainable forest management standards
- Impacts on habitats
- Climate change
- Common Agricultural Policy

This illustrates that climate change is one of many influences and factors that land users must consider, and will be prioritised accordingly.

Maladaptation

Adaptation actions which have an unintended negative impact on another sector or environmental consequence are known as maladaptations (similar to externalities in economic terms). Typically this would refer to an adaptation which increases energy usage – a common example is artificial snow-making in areas seeing a reduction in snowfall. While this is a valid and successful adaptation for the ski industry, the energy intensity of the practice (unless it is non-fossil-fuel based energy) makes this a maladaptation. In agriculture, potential for maladaptations also exist. Irrigation may in some situations be a maladaptation, if it places additional water stress on other regions or water users. Increased use of pesticides also has the potential to be a maladaptation if it increases pollution. Therefore extreme care and thorough planning must be made when adaptation strategies are put in place. Often it is the more reactive (rather than anticipatory) adaptations that are maladaptive, as less consideration may have been given to the consequences of the actions.

This suggests that the main options currently available for achieving the sorts of reductions in carbon footprint that are likely to be required requires either offsetting carbon sequestration or a reduction in production levels. These would both reduce the food production possible per unit area. Clearly in the longer term, it would seem to be necessary to develop different types of agricultural system that are more efficient in terms of their use of carbon. We discuss this further below.

Box 5.2 Climate Change Implications of the Scenarios

Intensive management
Returns to farming are high while at the same time the government is pursuing a vigorous policy to mitigate and adapt to climate change. This suggests a more intensive, higher technology approach that achieves the required reductions in GHG emissions without depressing production levels excessively. This could involve intensive livestock production levels in modern highly regulated buildings. Clover incorporated into rotations or anaerobic digestion may offer ways of reducing GHGs while maintaining fertility levels.

Exploited
Farms are left relatively free to pursue activities that can maximise their profits. We anticipate that oil prices and prices of inputs that are heavily dependent on oil are higher than at present. This will give an incentive for changes to be made to production systems and thus be likely to reduce carbon emissions. But N2O and CH4 emissions would be likely to remain relatively high. In the longer term, this will lead to higher rates of climate change and higher temperature increases, but this will have greatest impact beyond 2028.

Lean and wild
With lower returns to farming, and lower land prices, targets to mitigate GHG emissions are likely to be met by reductions in production levels and the operation of more extensive agricultural systems. Areas of land, such as peat soils, whose cultivation causes high GHG emissions, will be taken out of production. Land may be put into forestry in order to sequester carbon or used for biomass for renewable energy production.

Neglected
Weak regulation demands has little impact on agricultural systems and GHG emissions continue unabated. Again, this will be a caused of more extreme climate change in the longer term, but beyond the period to 2028.

5.2 Agricultural systems and returns

This discuss leads us to suggest some general conditions for farming in 2028:

- Higher but variable commodity prices
- Higher input costs, especially energy (feeding directly into a variety of costs such as heating, fertiliser, machinery operations), but we should also expect that labour costs will continue to increase.
- Availability of better technology: GMOs, information (especially spatial)
- More variable climatic conditions
- Some demand for land for biofuels
- Demand for higher quality products, such as ‘niche’ or ‘local’ products but larger markets for ‘quality’ products through mainstream outlets
- Increased national food and energy security lobby

- Continuing biosecurity concerns
- More open world trading conditions, but …..
- – potential trade bans from disease and countries where production conditions are not guaranteed
- Government climate and environmental policy
- Stronger resource protection policies (carbon, water, nitrogen, phosphate)
- Possibly weaker biodiversity policies in UK, more targeted and selective

Agricultural land area

- Removal of set-aside
- Greater competition for land for agriculture: how much land will come back into agricultural production?
- Some demand for land for biomass and possibly biofuels
- Water quantity and quality constraints (WFD)
- Competition with biodiversity

Agricultural systems

- High energy costs – efforts to reduce energy intensive inputs
- Intensity of production (prices / (fertiliser) costs)
- Substitution of information for physical inputs
- Continued increase in labour relative to machinery costs
- Continued pressures to reduce fixed costs
- Some adoption of GMOs
- Investment in research and development – begins to generate higher yields with lower inputs

Agricultural businesses and structure

- Increased market and production risks
- Increased economies of size
- Separation of land ownership from business structure
- Business specialisation on enterprises within same physical areas

These pressures would seem to indicate a need to development new types of agricultural system. In the post-war period, there was a very substantial investment in agricultural production and extension. Government heavily involved at all levels. This changed considerably in response to the problems of food surpluses and environmental concerns from the early 1980s, since when much of the agricultural research, development and extension system has been dismantled or privatised. The level of government commitment to agricultural production research has weakened and there has been a reorientation towards research on the environmental impacts of agriculture. We have argued above that the reduced rates of growth in agricultural yields are probably a reflection of this reorientation.

Other approaches towards agriculture have been explored. One major challenge is to find efficient ways to cycle nutrients within farming systems, given the high costs of externally purchased inputs and the potential damage from nutrients that are released from the system. Organic farming has become more significant, but the volume of research into organic production remains relatively low. There is an inevitable element of path dependency that governs the way in which agricultural systems develop. The long history of research and development has taken agricultural

technology and systems in a particular direction that appears to be less well suited to the conditions that are likely to face agriculture in the coming years. This clearly indicates a need for a reorientation and renewed investment in agricultural research and development. The need for more and better funding for Agricultural knowledge, science and technology has recently been recognised and accepted by the UK government in the International Assessment of Agricultural Knowledge Science Technology for Development (agassesment.org 2008).

Having said that, it is less obvious precisely what form a new approach towards agricultural technology and systems should take. The Strategy Unit (2008, p16) has recently commented on the complexity of the relationships between GHG emissions and agricultural systems. For instance, evidence suggests that intensive poultry production uses lower levels of primary energy and emits lower volumes of GHGs that either free range or organic production per kg of product. This arises because organic and free range chickens take more time to reach their slaughter weight and because more intensive units fit more birds into a give space.

It is perhaps tempting to assume that the most environmentally sensitive forms of agricultural production will be small scale and extensive, but this is certainly not always the case. Large scale operations can achieve very high levels of environmental control and economies of scale in the generation of energy and management of waste. They will also benefit from the traditional economies of size with regard to agricultural production process. The point is illustrated by two recent examples of very large investments in different types of agricultural production. 'thanet earth'[23], a hi-tech greenhouse complex, is being constructed by Fesca Group Ltd on the Isle of Thanet. £80 million is being invested in a 91 hectare site. Production will use hydroponic techniques in fully controlled glasshouses. Energy supply will be by a combined Heat and Power installation that will provide sufficient electricity for 50,000 homes and the CO2 will be absorbed by the plants. Robert Wiseman Dairies[24] have recently opened a new dairy on a 21 acre site at Bridgewater, based on £100 million investment, which will process and pack almost 10% of the nation's raw milk. Plastic milk bottles are manufactured on site. There will be water treatment and effluent plants on site. These sorts of facilities have the potential to alter the context within which agricultural production and processing is undertake much more widely.

[23] http://www.thanetearth.com/pdf/thanetearth_sept07.pdf
[24] http://www.wiseman-dairies.co.uk/pdf/Bridgwater_Formal_Opening_Release_Final.pdf

A recent review of the environmental impacts of alternative agricultural systems (Tuomisto *et al..*, 2008) suggests that an 'optimal' farming system, in terms of environmental impacts, might include the following aspects:

1. High yields to reduce total land requirement
2. Creation of non-crop habitats
3. Versatile crop rotation including crops with high root biomass and cover crops
4. Reduced/non tillage
5. Use of organic fertilisers
6. Anaerobic treatment of manure
7. Use of anaerobically treated sewage sludge/biowaste as fertiliser
8. Mixed farming

While no system is likely to adopt all these elements, they may point towards the directions that systems may take in response to increased environmental pressures. One possibly counter-intuitive aspect is the aim for higher yields. This emerges from the evidence that while organic systems have come to be recognised as having less environmental impact per unit area, they are often no better in terms of environmental impact per unit of output. In a global context within which there are strong demands for increased food production, as well as demands for land to support the production of renewable energy, then higher yields will be a more likely objective in the future than it has been in recent years. But assuming high energy costs and concerns of the impact of chemicals on the environment, then the implication is that this will be achieved through more 'organic' approaches. But this does not imply a move towards 'organic farming' which, as noted, tends to have lower yields and to involve considerable land cultivation, which conflicts with the goal of reduced tillage. Thus this seems to imply a search for rather different sorts of agricultural systems from those which have been developed in the past.

Box 5.3: Agricultural Systems and Returns Implications of the Scenarios

Intensive management

Higher commodity prices will lead to more intensive agricultural systems. There will be a premium on achieving the 'best' use for all available land areas as judged from a 'pro-environmental' perspective; agriculture will be 'multifunctional'. It would seem likely that new technology will be called upon to deliver this level of outputs, although it must be possible that the 'pro-environmental' policy will place limits on the range of technological innovation that is acceptable in terms of such issues as GMOs or animal welfare. The pro-environmental policy environment may enable smaller businesses to survive but this may not be the case if the high degree of control over production systems necessitates large, intensive, high technology systems, especially for livestock production.

Exploited

Under the Exploited scenario, profit maximisation and technological innovation are given free reign, even if they compromise environmental quality and longer term resource conservation. It seems likely that this will tend to favour large scale farming businesses, although the higher prices may permit the survival of smaller business operations where costs may be lower because they are not required to adopt low environmental impact innovations.

Lean and wild

This scenario will be characterised by extensive systems. There is much less pressure on land and so environmental objectives can be achieved by reducing production intensity or even taking land out of production entirely. There will be serious risk of land abandonment, especially in the uplands, but agri-environmental policies may be expected to guide land uses either maintaining traditional upland farming, ecosystems and landscapes, or else they may facilitate the transfer of land into large scale conservation where agricultural production activities are substantially removed and areas are allowed (or managed) to develop into new landscapes and habitats. This may be achieved by the accumulation of land areas into a single ownership, or else by means of very long term agreements with existing landowners.

Neglected

This is the context where we see a mix of land uses across rural areas. Farming may be profitable, but only where it is undertaken on high quality land by well managed and equipped businesses. These will demand very high management standards and comprehensive collection and application of information about production conditions at a very detailed scale. Adjustment to higher energy and input costs will be by means of extensification, use of fallows, clover leys and avoiding unproductive areas of land. We can expect the development of extensive ranching systems in the uplands, where production takes place at all.

5.3 Agri-environment schemes

Agri-environment schemes and policies may be expected to develop in a variety of ways:

- Cross-compliance rules required independently of payments when and if the Single Farm Payment is phased out.
- Potentially increased Pillar 2 expenditure on agri-environment schemes linked to a decline in Pillar 1 spending, with a greater emphasis on climate and resource protection than on landscape and biodiversity.
- Reduced incentives for farmers to remain in agri-environment contracts in the face of more profitable agricultural production options, threatening the maintenance of the environmental enhancements that have been achieved by agri-environment schemes to date.
- A shift away from a narrow focus on conservation on sites that happen to carry rare species or habitats towards a wider countryside approach and efforts to achieve conservation at a larger scale. Efforts to build the resilience of the countryside against threats associated with climate change, pollution and low levels of water availability.
- Stringent requirements for water quality under the EU 'Water Framework Directive' may necessitate major changes in the use or re-cycling of nutrients in farming systems in particular river basins, or changes in policy.
- Reassessment of the role of permanent conservation measures that can persist against the increased volatility in climate and the financial environment, perhaps by land purchase. This creates a need to decide how the most critical areas should be identified for permanent measures.

Under the 'pro-environment' scenarios funds are made available for the implementation of substantial agri-environment programmes, but the approaches adopted will be quite different. The implications are elaborated in Box 5.4.

Box 5.4: Agri-environment Scheme Implications of the Scenarios

Intensive management

The pressures for intensive agricultural production threaten the quality of the rural environment in a variety of ways and the role of agri-environment policy is primarily to mitigate the impact of intensification. This becomes more significant if the cross-compliance leverage of Single Farm Payment is lost, although it seems quite probable in the event of fundamental reform of the CAP, the cross-compliance requirements would be re-established as regulations enforced by penalties. Agri-environment schemes are then most likely to offer payments for extensification and the removal of critical areas of land from production, such sensitive habitats, areas adjoining watercourses or peatlands. There may be some targeting on catchments at risk of failing to meet water quality standards. The cost of the scheme could be relatively high, but it is assumed that this would be met where government policy is favourable towards agri-environmental policy.

There is an argument as to whether higher levels of government expenditure on agri-environment schemes promote higher voluntary environmental investments, or whether high government expenditure may crowd out voluntary expenditure. The view may be taken, perhaps by The Crown Estate, that while government takes on the

responsibility for environmental enhancement and maintenance, that private organisations no longer need to; that the responsibility for environmental stewardship has been taken on by the government by commoditising then environment, so that private organisations will only do what they are paid to do.

Exploited
This scenario represents the greatest threat to rural environmental quality. It would seem unlikely that in this context government would continue to operate an active and wide-ranging agri-environmental scheme. Voluntary schemes are expensive given the high opportunity costs of land taken out of agriculture and so regulation could be primary protection for environment. This may be acceptable to a government that is less committed to environment. What schemes are implemented will necessarily be highly targeted given the limited funds that are made available for agri-environment policy. Schemes are likely to be operated on a more competitive basis, perhaps along the lines of the use of the Environmental Benefit Index under the Conservation Reserve Program in the USA. The policy approach taken is likely to depend on whether government's lack of commitment to environment reflects an unwillingness to allocate funds for environment or a simple lack of concern for environmental values.

Lean and wild
This scenario gives considerable scope for wider-ranging schemes influencing land management across a substantial proportion of the agricultural land area. Regulation may be less necessary given the relatively low threat from pollution and an active agri-environment scheme. A major threat to the environment is associated with the low returns to farming and the lack of management and abandonment of agricultural land. This will be most acute in the uplands. Thus the prime focus of agri-environment schemes will be to support the maintenance of environmentally friendly farming systems that are not profitable under market trading conditions. But support will need to be qualified in order to avoid supporting environmentally harmful intensification and to meet any World Trade Organisation rules that are still applied.

Neglected
Again, the threat to the environment is associated with neglect and abandonment, but given that government has little interest in environmental conservation, the problems are likely to remain unaddressed. Depending on the rationale behind the lack of government intervention, as between lack of willingness to allocate funds or a lack of concern for the environment. In the case of the former, government could implement a regulatory approach, but this may only have a limited impact where the environmental requirement is to increase levels of land management rather than to prevent certain actions.

5.4 Key issues for Estate Forestry

1. The long-term nature of forestry.

A twenty-year time horizon is short for foresters – half the length of a reasonably fast growing conifer rotation and less than a quarter of the time to maturity of many broadleaved species. The pattern of timber production around 2028 is largely determined by trees already growing. Although changes in management in response to new circumstances e.g. market fluctuations, government incentives, may accelerate or retard harvesting plans to some extent, without significant increases in production costs, fundamental changes in estate forestry policy (apart from an unlikely call for substantial deforestation) require a long period to be brought to fruition. The continued pursuit of a multi-purpose forest policy, with its inherent flexibility, seems desirable.

2. Possibilities for deferral of action

The general long-term outlook for British forestry is widely thought to hold the prospect of sustained improvement of returns. On certain scenarios, however, there could be periods of decline in the fortunes of forestry, as in the late 1990s, and most estates in those circumstances find forestry unprofitable – and many do so in much more favourable times. In some cases, forest management continues, cross-subsidised from other enterprises or wealth but, perhaps increasingly, forestry enterprises are expected at least to break even on costs, and reduced income will create major cash flow problems. There may be opportunities for remunerative diversification; management costs may be pruned; silviculture may be changed, but the point may be reached when forest activity has to cease. With most enterprises, that would mean the end of the business. A special feature of forestry is that its main capital (trees) (other than very young or some over-mature ones) will continue to gain in volume and in value even if totally neglected for several years. In extreme cases, management costs can be reduced to zero for a decade or more and resumption of activity eventually will enable most of the original potential of the forest area to be realised. But there are limits! The history of British forestry over the last two centuries shows that neglect for too long can have disastrous consequences for productivity and that if the period of nil management begins with a poor quality wood, it will end with even poorer quality material and rehabilitation will require substantial capital injection.

3 Volatility of trading conditions

It is often contended that forestry as an investment class displays less volatility than other forms of real estate. Even if that is correct, as timber price fluctuations in the last fifty years have shown, annual income may be volatile and variation in the quantity of produce harvested may be necessary to reduce variation in cash flow. Moreover, although many commentators now expect long-term real price increased for many categories of forest produce of good quality, it is worth remembering that the trend of timber prices over the past 40-50 years has been downward in real terms – and, for much of the period for many products, downwards in nominal terms too. Some estates have successfully diversified to compensate for this and the forestry enterprise as a whole has continued to add value each year.

4 Trading in forest land

Many traditional private forest estates are characterised by very little change of use between agriculture and forestry for a long time past. Inherited land use patterns have

remained. Traditional estates, by and large, have not purchased significant areas of land for tree planting and sales of woodland have commonly been confined to small-scale disposals for development – unless an estate were being broken up to meet tax or other financial liabilities. It is assumed that The Crown Estate is not likely to depart substantially from a policy of limited trading in forest land but that, under certain scenarios, forestry might be considered an appropriate land use for a significant area of former agricultural land.

5 Location and regional variations

From a forestry perspective it is difficult to generalise about an estate which includes land over a wide are from the south of England to the north of Scotland. The Crown Estate not only spans very different physical conditions, with different conditions for tree growth affecting species choice and management, but also different forestry traditions and policies, and different locations in relation both to wood processing plant and population centres. All such differences have to be reflected in local management decisions.

6 Relative stability in forestry and forest policy?

The crystal ball for forestry in 2028 is very cloudy. Nevertheless, having reached the current position of policies strongly in favour of sustainable, multi-purpose forestry, with signs of some improvement in timber market conditions and the possibility of a market for hitherto worthless rubbish, it is perhaps reasonable to look forward with some hope of at least relative stability. If there are to be significant changes, perhaps they are more likely to be generally favourable to forestry (e.g. greener policies; reduction in global timber supplies) – unless the trigger is world recession, in which case the ability of forest owners to 'shut the gate' for a while may be a major advantage.

7. The problem of small woodland blocks

Many very small areas of woodland are not doubt incorporated into farm tenancies and, if managed at all, will be viewed mostly as amenity woods, with the occasional poles or fuel for use on the farm. Such areas are important landscape and wildlife features, but have limited wood producing capacity. Of potentially greater interest for wood production are blocks of woodland on relatively isolated estates – blocks which in themselves are too small to warrant significant attention from the centre, but which could have local production potential. At present, many have not been actively managed and the timber quality of the trees may not be high. In the context of a strengthened woodfuel market, however, there might be a case for improving such woods and creating significant possibility for high quality timber production – while retaining most of the existing non-timber benefits. As an alternative to trying to co-ordinate all such activity from the centre, it might be worth considering whether some of these woodland blocks could be added to farm tenancies, with The Crown Estate providing assistance with marketing.

The interpretation of forestry in the scenarios depends on the assumption that is made with regard to timber prices and financial returns to forestry. It seems likely that timber prices would tend to track commodity prices more generally, although this need not be the case.

Box 5.5: Forestry Implications of the Scenarios

Intensive management

Assuming that timber prices higher in real terms across the board, the pro-environmental policies favour woodfuel; timber for construction; tighter certification scheme; wildlife conservation; landscape protection; carbon capture and green tourism. Rural tourism and leisure market are flourishing given the public interest in environment. Forestry has no difficulty in fulfilling its overall goal of adding value to the estate in a sustainable way, with 'best practice' management. Forestry costs more readily covered than now. Wooded areas on isolated estates once poorly managed are now managed effectively for environmental goals but with a view to good quality timber as well. Any marginal adjustment for climate change readily accommodated. Little change in land use pattern, given the strong demand for agricultural land.

Lower returns to forestry would make relatively little difference except the objectives for the management of the forest estate would give a greater emphasis to environmental over financial objectives.

Exploited

Assuming that timber prices lower in real terms, then timber and non-timber income fails to cover forestry management costs. The weak environmental policy means that there is no government aid for forestry in any form. Management costs are cut by concentrating on key areas e.g. most visible, or most valuable mature timber. Some harvesting delayed and management adjusted accordingly. Some harvested areas receive less subsequent management.

Higher timber prices might promote some greater interest in commercial timber, but they would be unlikely to make a major impact on land use unless prices were exceptionally high as compared with historic experience.

Lean and wild

As above, apart from last point on land use:
Some land becomes sub-marginal for agriculture and leads to an expansion of the forest area where forestry is seen as an alternative to agriculture. This presents opportunities for:

- Landscape etc. improvement;
- Increase viability of certain forest blocks;
- Wood fuel production;
- Background for urban development, including recreation.

Where timber returns are also low, then the incentive for forestry relies wholly on its environmental value.

Neglected

The position is essentially similar to that in the Exploited scenario but it is seen as more permanent condition. Some forest areas remain unmanaged for period of many years. A few areas abandoned by agriculture are planted with trees, but many opportunities not taken. Owners actively seek opportunities to dispose of areas of forest (and agricultural) land for development. The forest estate depends on cross-subsidy from the urban estate, both for annual costs and for investment e.g. in land, on

the basis that depression will eventually lift, and there are good opportunities to consolidate the rural estate.

If forestry returns are high then there will be possibilities for expansion of the commercial forest estate on areas of land that might otherwise be abandoned from agriculture.

5.5 Non-agricultural activities

The alternative scenarios will have an impact on the range of opportunities for tenants on The Crown Estate to develop income from non-agricultural activities associated with both the likely characteristics of consumer demand and the costs facing consumers and so influencing their choices. While not explicitly defined by the scenarios, there will be a general relationship with levels of economic growth. Higher income levels will tend to stimulate the demand for higher quality and added value products that can be sold at a price premium. This will create opportunities for businesses on The Crown Estate both to sell value-added products directly to consumers, whether through farmers' markets or through the internet, or to sell such products into the supply chain. Higher incomes may also be associated with more leisure time and increase the demand for rural tourism, while, as already being argued at present, higher energy costs would raise the costs of transport and so make UK tourism more attractive to UK residents. Of course, high travel costs will tend to reduce the numbers of overseas visitors coming to the UK, but it is assumed that UK residents would be more likely to engage in farm-based and rural tourism than overseas visitors who will be more attracted by internationally recognised sites and localities.

Box 5.6: Non-Agricultural Implications of the Scenarios

Intensive management
This scenario involves relatively high commodity prices which we assume will tend to be associated with relatively high rates of economic growth, although this need not necessarily be the case. At the same time, pro-environment attitudes will to some degree at least, and especially in the context of higher rates of economic growth, influence consumers to purchase more environmentally friendly products. It is possible too that tenants will be able to combine the creation and maintenance of attractive and biodiverse local environments through participation in agri-environment schemes, with the provision of complementary tourism opportunities and services.

Exploited
In the context of relatively lax environmental standards, the costs of travel fail to represent the full environmental costs so that there is less of a boost to local tourism activities. The weaker pro-environmental attitudes on the part of consumers reduce the premia that are available through the production of higher quality or environmentally friendly products. This then re-emphasises the focus of agricultural businesses of the bulk production of agricultural commodities. The implication is that while there will still be opportunities for non-agricultural enterprises, they are less likely to be complementary to and supportive of land management on The Crown Estate.

Lean and wild
The pro-environmental attitudes of the public mean that there is a demand for higher quality agricultural products. The lower production intensity of land use also means that there are fewer potential conflicts between agricultural production and provision for public access and recreational provision on the land. And government schemes are likely to be available to support this, especially in the uplands.

Neglected
The limited public interest in the rural environment means that, as in the Exploited scenario, there is relatively little connection between non-agricultural activities on The Crown Estate and the management of the land. Estate buildings and land will be potentially available for non-agricultural activities in view of the extensive nature of agricultural production and the level of demand will depend on their location relative to towns and cities and the level of economic activity and incomes.

5.6 Land values and prices

The value of the land of The Crown Estate as an asset is a critical factor for the performance of The Crown Estate as a whole. The Crown Estate holds a portfolio of land and property assets that must be managed in order to maintain its value and strength. This means that in principle assets should be sold where the long term income that can be gained can generate a higher return, consistently with The Crown Estate's objectives, than the return gained from the asset while remaining in Estate ownership.

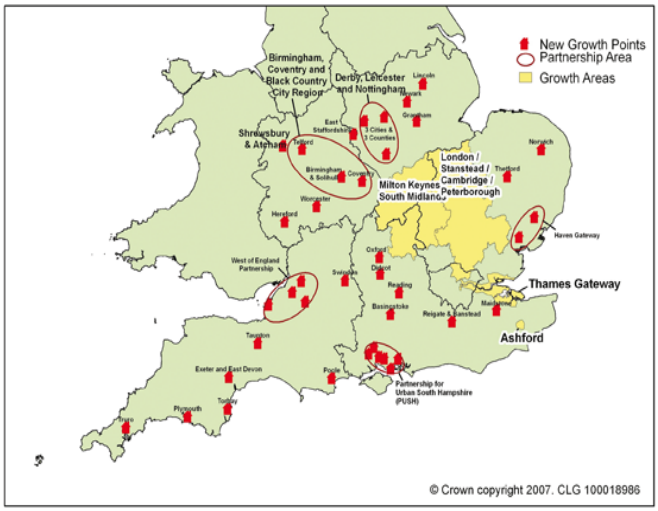
Land for agriculture
The resurgence of agricultural land prices against the trend in commercial property prices has made agricultural land a very good investment at present. The property value of the Rural Estate grew by 26.5% between 2006/07 – 2007/08, while the value of the Urban Estate fell by 0.2%. But whether or not this growth in rural land prices will be sustained in the longer term and whether or not agricultural land represents a good investment in terms of growth of asset value at present prices are less obvious. We have argued that the long term prospects for agricultural output prices are relatively strong, but not guaranteed. But the value of land depends on its net income earning potential rather than the price at which its products are sold, and there is a real possibility that inputs costs may rise to counteract the gains from higher output prices. Given the relatively poor performance of other asset classes, there has been a considerable volume of funds directed towards investments associated with commodities and it is impossible to know at this stage to what extent this will depresses the returns gained on this investment flow.

The other logic for engagement with the agricultural land market is where it opens the possibility of expanding businesses so as to increase their returns or of restructuring to generate a more efficient pattern of land holding. Given the increasing complexity and sophistication of the ways by which businesses may gain control over land in order to undertake agricultural production, the historic preoccupation with the area of individual holdings may be less fundamental to a landed estate in the future. Investment in non-land assets and businesses may be more productive.

Land for development

Probably the major opportunity for increased capital values arises when agricultural land is given planning permission for new development. It is widely argued that, notwithstanding the present depressed state of the housing market, that there is a long-term need for the production of more housing. This reflects not just the high level of house prices that has been experienced in recent years, but also the projections of continued increases in household numbers to 2026 and beyond. The Government has set out ambitious targets for new house building and in 2007 announced an aim of delivering 3 million new homes in England by 2020. These are to be provided in a variety of ways, but the Government has identified Growth Areas and new Growth Points as a focus for new development. These are illustrated in Figure 5.4. It would clearly be possible to map these areas against Estate property, and The Crown Estate may have already done this. The Government has also emphasised the need for the provision of affordable homes in rural areas which will be likely to create some smaller scale opportunities in other locations.

Figure 5.4: Map of Growth Areas and New Growth Points



Source: Communities and Local Government (2007)

The delivery of these targets will clearly depend on the state of the economy generally, the impact of the present recession in the housing market and the availability of credit. This would seem likely to delay delivery, but the underlying growth of population and household numbers would seem likely to mean that substantial levels of house building will ultimately be required in the longer term. What is less certain is the degree of Government intervention in the process, the environmental constraints that are imposed on construction, the extent to which development is steered towards particular locations and the extent to which planning gain is extracted by Government and the consequent implications for land prices. These factors are likely to be quite different in the different scenarios (Box 5.7).

Box 5.7: Land Values Implications of the Scenarios

Intensive management

Under this scenario, land values are generally high, although they may be affected in particular contexts by environmental and planning constraints. The need to develop relatively high technology solutions to address environmental problems in agriculture might suggest that investments need to be directed towards building business structures and capital, rather than attempting to expand the area of The Crown Estate.

Government is likely to steer opportunities for housing development towards low environmental impact areas, away from sensitive habitats or floodplains. There will be more focus on the development of settlement patterns that effectively link residential and employment patterns, and reduce transport volumes. There may also be a reconsideration of the role of government with regard to the spatial distribution of population and economic activity across the country in the light of altered environmental priorities and constraints. Government is also likely to enforce stricter environmental standards on construction. This might suggest that development land prices will be high in the more limited locations where development is permitted, but profitability may be affected by the costs of meeting stricter environmental constraints, and a more interventionist Government may do more to claw back planning gain from private developers.

Exploited

High agricultural returns with little policy restraint will lead to high agricultural land prices and there are arguments for seeking to expand the area of The Crown Estate under these circumstances. The volume of land development will be relatively high. Whether or not development land prices are high will depend on the degree to which the market is liberalised. A radical free market approach would have the potential, at some point, to expand supply to such an extent that the difference between agricultural and development land prices would fall considerably. However, it is hard to imagine that this would happen to this extent given the long history of planning control that has been acceptable across the political spectrum.

Lean and wild

Successful agricultural businesses will need to operate across large areas of land in order to be profitable, but this may not be dependent on landownership. Other types of tenancies and contracts will be available. Land agricultural prices are lower and conservation interest higher than in other scenarios so that conservation organisations become more active in securing control over large-scale areas for landscape and habitat restoration and creation. But generally these areas will continue to need agricultural management and conservation organisations will tend to contract this out to existing agricultural management businesses. Housing development will still be subject to relatively strict environmental limits, in terms of location, settlement patterns and construction methods. This will be similar to the circumstances in the Intensive Management scenario.

Neglected

Agricultural land values are low and farming businesses will need to achieve scale in order to be profitable, but, as noted above, this need not necessitate landownership. The lack of public interest in environment and conservation means that there is

relatively little activity by conservation organisations. The process of housing development is similar to that under the Exploited scenario, although the lower values of land for farming might encourage lower density housing development and the use of more greenfield sites. So the area of land potentially taken for housing development may be higher while the price per hectare might be lower.

6. Prospects for individual businesses

In this section we review a number of issues that arise for the operation of individual businesses.

6.1 Farm types and budgets

Introduction

Reflecting the diversity of the portfolio of the rural holdings of The Crown Estate, our work in this section explores the possible impact of the four scenarios on farming businesses on the Estate over 20 years to 2028. In order to do this, we devised a series of budgets to represent the changes in prices of commodities, prices of inputs and availability of resources including land.

Method

Our baseline budgets were derived from grouped Farm Business Survey (FBS) data relating to selected groups of farms in specified geographical areas intended to replicate the farming conditions experienced by tenants of The Crown Estate. Whilst it is possible that some of the farms in the FBS are tenants of The Crown Estate, no attempt was made to specifically include such tenants. For reasons of confidentiality, it would not be possible to identify farms in this way for this purpose. The following four groups were identified:

- Cereals farms in Lincolnshire, Yorkshire and Humberside
- General Cropping farms in the East Midlands and Cambridgeshire
- Dairy farms in the South West
- Grazing Livestock farms in Severely Disadvantaged Areas (EU designation)

These farms represent the main types of farming carried out by tenants on the Estate, namely combinable crop production, production of more intensive crops including potatoes, milk production and hill farming, and all in the areas where these activities are most likely to be located. The budgets constructed relate to whole farm businesses rather than individual holdings that may comprise a part of a larger business.

Using the approach described above, baseline farm budgets included at least 50 farms in each group providing reassurance that the results were representative of the wider category. The baseline year was taken as 2006 as this is the most recent year for which accurate information is available. Commodity prices, for both agricultural production and inputs, have increased in the intervening years giving a relatively low baseline level of income.

For 2028, budgets were prepared for the four scenarios, but with two different approaches to the treatment of the pro-environment conditions, giving six scenarios in total as illustrated in Table 6.1.

Table 6.1: Scenarios Used for Farm Budgets

Scenario	Commodity Prices	Environmental policy	Environmental policy approach
Intensive management _Regulation	High	Pro	Regulation
Intensive management_Payment	High	Pro	Positive payments
Exploited	High	Indifferent	-
Lean and Wild_Regulation	Low	Pro	Regulation
Lean and Wild_Payment	Low	Pro	Positive payment
Neglected	Low	Indifferent	-

In the scenarios with high financial returns, the scenarios were 'intensive management' in the case of pro environment government policy and 'exploited' in the case of a negative policy approach. In the case of low financial returns, the scenarios shown are 'lean and wild' and 'neglected' respectively in the case of pro and negative environment policies. However, over the next twenty years, there is scope for considerable change in environment policy, especially in the relationship between payments to producers and legal requirements placed upon them. Intensive Management_Regulation and Lean and Wild_Regulation allow for a ten per cent increase in production costs which represents an increase in costs arising from constraints introduced by a regulatory approach towards environmental policy. Intensive Management_Payment and Lean and Wild_Payment recognise that agri environment schemes may be used to reward producers. This could be a payment for taking land out of production in an agri-environment or set-aside scheme. While payments may be set so as to represent the level of income foregone through scheme participation, in practice is it likely to generate some overall increase, where payment exceeds costs or where farmers are able to take less productive land out of production. The scenarios are summarised in table 6.2 below.

Table 6.2: Scenarios Used in the Preparation of Budgets

Financial Returns to Agricultural Land	**High**	**High**	**Low**	**Low**
Pro-Environment Policies	**Pro**	**Indifferent**	**Pro**	**Indifferent**
Scenario:	**Intensive Management**	**Exploited**	**Lean and Wild**	**Neglected**
Wheat Prices[25] (Crop Output; or Livestock Costs Lowland: % change, on 2006 in real terms)	250 £/t +300%	250 £/t +300%	60 £/t -20%	60 £/t -20%
Livestock Output Prices (% change)	+100%[26]	+100%	-10%[27]	-10%
Livestock Costs - upland (% change)	+30%[28]	+30%	0	0
Oil Prices (Machinery Running and Crop Costs: % change)	200 $/bl[29] +300%	200 $/bl +300%	100 $/bl[30] +50%	100 $/bl +50%
Labour Costs (% change – 1% p.a.)	+22%[31]	+22%	+22%	+22%
Machinery Depreciation (% change)	+30%[32]	+30%	0	0
Government Intervention A: Cost increases	+10%	0	+10%	0
Government Intervention B: Output increases	+10%	0	+10%	0

The results are shown in terms of Farm Business Income (FBI). This represents the financial return to all unpaid labour (farmers and spouses, non-principal partners and their spouses and family workers) and on all their capital invested in the farm business, including land and buildings. FBI is the standard indicator of the financial performance of farm businesses, and therefore allows comparison between the projections and published results from the FBS. Unlike previous income measures, FBI shows incomes on an 'as is' basis with rent costs included if paid but not imputed for owner occupied businesses. Therefore, the budgets do not explicitly show rent

[25] Based on commodity price ranges since 1970 (HM-Treasury)
[26] 1/3 of the possible increase in Wheat Price
[27] Lowest price seen in the last 10 years
(Defra - Indices of Prices of Agricultural Commodities and Means of Production)
[28] Same as estimated increase in Machinery Depreciation Costs
[29] Press report (Financial Times, 8 June 2008)
[30] OECD 2017 projection (OECD-FAO 2008)
[31] Long-term trend (estd.)
[32] Capturing 1/10 of the increase in crop outputs

paid but, allowing for income volatility and a lag between receipt of income and negotiation of rent, rents would tend to track the observed changes in FBI.

To provide results that are consistent with Defra and Rural Business Research publications, the farm budgets exclude Single Farm Payment and activity associated with diversification outside agricultural production. Many of the farm business income figures presented are negative. This is not unusual for individual years and farming businesses often cross subsidise from profitable diversification and the Single Farm Payment to less profitable agricultural production.

Whilst it is difficult to project the possible political developments that will determine the value of Single Farm Payment made to farmers over the next twenty years, the transition to flat rate area payments in all EU member states will simplify comparison between businesses. We assume that the value of the payment will decline over time.

Since the opportunities for changes in income from diversification activity are linked more closely to the location of the farm and the availability of farm resources than to the farm type, these are considered independently to the farm type budgets.

Assumptions

Prices are given in terms of today's general price level, i.e. inflation to 2028 is ignored. Crop and livestock output prices and input prices were set reflecting the earlier discussion and the ranges that have been experienced in the past.

We assume relatively stable levels of yields. The evidence of cereal yields suggests that growth has diminished, perhaps reflecting the lack of investment in crop genetic advancements. And it should be recognised that unfavourable economic conditions, such as those prevailing in parts of Eastern Europe in the 1980s and 1990s can result in falling crop yields. Long-term exposure of the UK agricultural industry to the low financial returns scenarios could result in reduced fertiliser and spray use giving a reduction in national crop yields. Conversely of course, increased concern about commodity supplies might stimulate renewed investment in production research, but this would have a long lag before significant impacts would be experienced in the field. However, at the same time, there are opportunities for the producers that are currently achieving low yields to improve to the standards of those currently growing higher yields. Similarly, while unit yields of milk and meat have increased in recent years, environmental constraints on forage use have limited any increase in yield per unit area.

Input costs were set on the basis of recognised independent sources of economic data; the low financial returns future energy price is based on OECD projections.

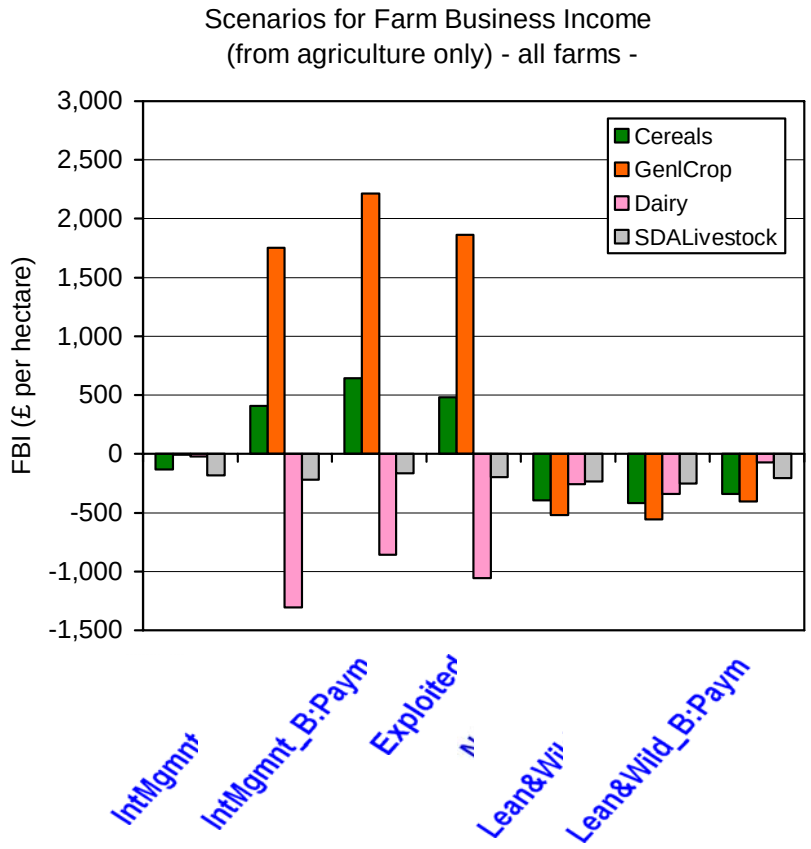
Based on observations of the change in the average size of farm businesses over the last twenty years, farm size is assumed to increase by twenty five per cent over the twenty years considered. Based on changes in technology and productivity, the increase in farm size is potentially greater than this, but business size tends to adjust relatively slowly in practice.

Agri-environment scheme payments, including Entry Level Stewardship and Hill Farm Allowance, are not included in the baseline budgets. However we adjust returns and costs in the pro-environment scenarios in order to represent their possible impact on farm budgets.

Results

The results can be seen in figure 6.1 below.

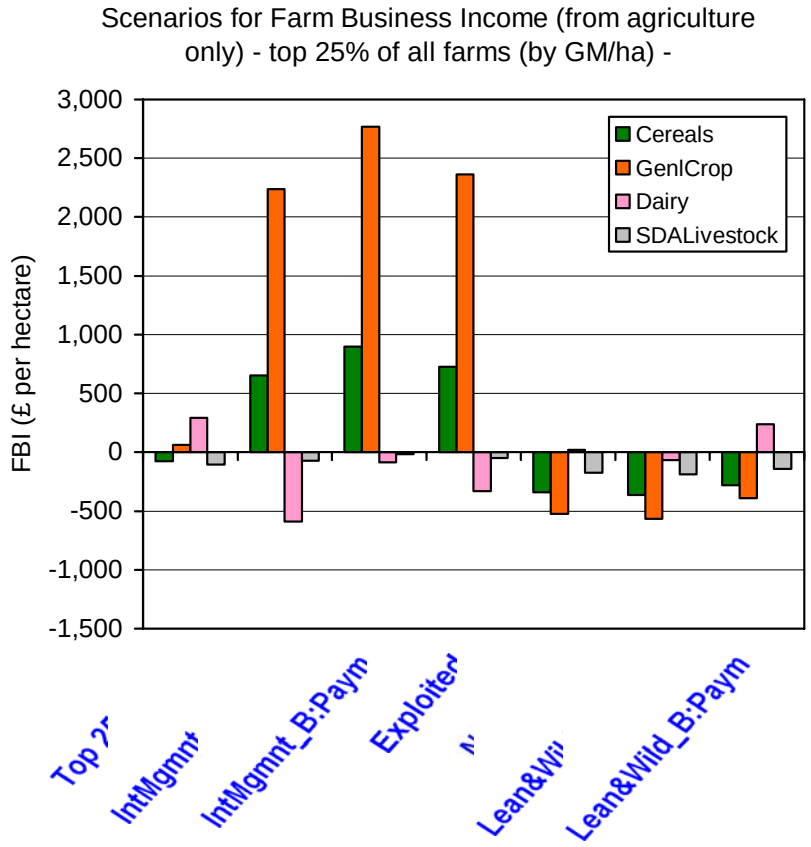
Figure 6.1: Budgeting Exercise – Comparison of Farm Business Income in 2006 and 2028 on All Farms



Results were also prepared for the top performing quartile of farm businesses to introduce the range of performance between businesses. These are shown in Figure 6.2. Consideration of the impact of the budgeted scenarios on the highest performing farms allows us to consider which farm types are most exposed to variations in the scenarios, and it provides and indication of the prospects of the businesses that are more likely to remain economically viable until 2028. Some of the differences in performance between farms is no doubt associated with the quality of the resources, especially land, that managers have available to them. But in practice, there is not a close relationship between land quality and business performance and it is assumed that much of the difference relates to the quality of management. This suggests that

there will often be scope for substantial improvement in performance by improving the quality of farm management.

Figure 6.2: Budgeting Exercise – Comparison of Farm Business Income in 2006 and 2028 on Farms in the Top Quartile (by Gross Margin per hectare)



Compared to the results of this exercise for all farms, all farm type groups gained in profitability, but the top performing arable farms noticeably improved profitability in the high output price scenarios. The top performing dairy farms responded more favourably to all scenarios, even returning to profitability in the Lean and Wild_Payment. The top quartile hill (SDA Livestock) farms showed rather less variation suggesting greater resilience to the changing external circumstances.

Leaving aside the inherent differences in profitability between enterprises, study of the top quartile group of farms suggests that there will continue to be a wide range of performance of Cereal and General Cropping farms, albeit exaggerated by the greater increase in crop prices than in livestock prices in the budget assumptions. Conversely, there is less scope for such variation in performance of the inherently less profitable, but nevertheless resilient, hill farms.

The assumptions that have been made in assembling these budgets are necessarily speculative; we are not seeking to project the actual conditions for businesses in 2028. Even if the prices used were to prove to be correct, there would be further changes in

farm systems and conditions. Our consideration of the results focuses thus on the relative changes observed.

The most obvious implication is that we cannot simplistically assume that higher output prices mean higher profit for all farm types. We see very different outcomes for the arable as compared with the livestock businesses. In general terms, the higher output price scenarios (Intensive Management and Exploited) gave rise to increased farm income for arable farm businesses, but this did not translate into improved profitability of livestock businesses. The arable businesses benefited from higher increases in the prices received for crops relative to the costs of inputs consumed. But the cost structures of the livestock businesses limited the opportunity to benefit from higher commodity prices. Of course, increases in livestock prices could outweigh this effect. The dairy farms, with exposure to feed, energy and labour costs saw reduced profitability within the budgeted conditions.

The low commodity price scenarios give reductions in Farm Business Income that are the converse of the high commodity price scenarios. Given that all achieve FBIs that are below the 2006 baseline, which was itself widely seen as unsustainable, it is reasonable to assume that these levels of income could not be sustained in the longer term.

Introducing the possible pro-environment policies as changes to output and costs in the "Intensive Management" and "Lean and Wild" scenarios, causes relatively modest changes to FBI. In common with current observations, scheme participation can provide some financial assistance for some farm businesses as illustrated by the hill farms that show an improvement in profitability in the favourable (increased output) "Intensive Management_Payment" but a reduction in profitability if costs are increased as shown in "Intensive Management_Regulation".

The exercise demonstrates the levels of risk associated with different types of agricultural production. The high input / high output general cropping farms saw the greatest differences in profitability as between the higher and lower price scenarios. This is because of the higher inherent value of the crops grown, and the fact that farms of this type carry high costs regardless of output. The risk on general cropping farms is accentuated by the perishable nature of some of the crops grown and the possibility of greater fluctuation in prices than for dry commodities. These findings are consistent with our observations of annual variation in profitability of general cropping farms from historic data. Among the livestock farms, a similar situation is seen on the dairy farms which prove to be subject to greater variation in profitability than the hill farms. This is mainly due to their exposure to the costs of externally purchased inputs, including grain for feed.

Discussion

The value of the farm budgeting exercise is that it provides an opportunity to explore the possible responses of farmers to future circumstances, rather than providing a reliable indicator of the extent of future change. The budgets illustrate the importance of prices to farm income as compared with the likely impact of environmental schemes. And we note that farmers will almost certainly be exposed to higher price

fluctuations in the future than has been the experience in the past. Clearly, further adjustments would be necessary in order to make the livestock businesses sustainable. This could arise for greater increases in livestock prices. This would certainly be expected within a closed economy, but may not eventuate in one in which prices are set by world trading conditions. There would certainly be reductions in rent levels and no doubt restructuring of businesses. But it also suggests that some sort of support scheme would be necessary if the majority of businesses are to remain in operation. This will especially be the case with regard to the upland farms.

Whilst the budgets do not take account of the likelihood of climatic variability and greater volatility in commodity markets, they illustrate the relative exposure of different types of business (especially the more intensive cropping and dairy farms) to such variations. However, it is likely that physical (for example investment in irrigation or drainage) and economic (for example adoption of trading mechanisms) mitigation measures will redress this variation to some extent.

The static relationships between inputs and outputs assumed in the budgets ignore the ongoing changes in technology applied in agriculture. While changes in the technology applied on farms may have been relatively slow under conditions of low farm incomes, it has probably accelerated with the availability of higher incomes enabling new investment and re-equipping of farm businesses on some types of farm.

As well as technical change, farmers also have the capability to alter their mix of inputs to adapt to changed circumstances. On an annual basis, spray and fertiliser inputs can be tailored to match expected crop prices or the forage to concentrate mix can be changed to influence milk yield. In the longer term, investment in machinery and buildings can allow a reduction in labour costs for a given level of output. In the future, the relationships between inputs and outputs will change for this reason.

Analysis based on the average performance of a relatively large number of farms in a group ignores the niche activities that will be important to a significant number of businesses. Whether organic, producing an innovative product line, or simply benefiting from a particular geographical location, these farms have the potential to outperform the average, albeit by taking greater risks.

There is every reason to expect the continuation of existing expansion of farm size. Machinery capacity and increases in productivity continue to drive farm expansion. There is an increasing trend for even the largest farms to share high capacity machinery such as combines, sugar beet harvesters and cultivation or drilling systems. (In fact it is often the largest farms that are most willing to innovate in this way). Changing occupancy practices, which include contract farming and stubble to stubble contracts, allow structural changes to occur even if land ownership and tenancy arrangements remain unchanged. Farm expansion will generally allow a reduction in unit costs of production, but analysis of farm income data also shows the potential for diseconomies of scale, especially when management costs are taken into account.

The most successful businesses in 2028 are likely to be those that understand and interpret the changes in the intervening years and adapt their business to the new circumstances.

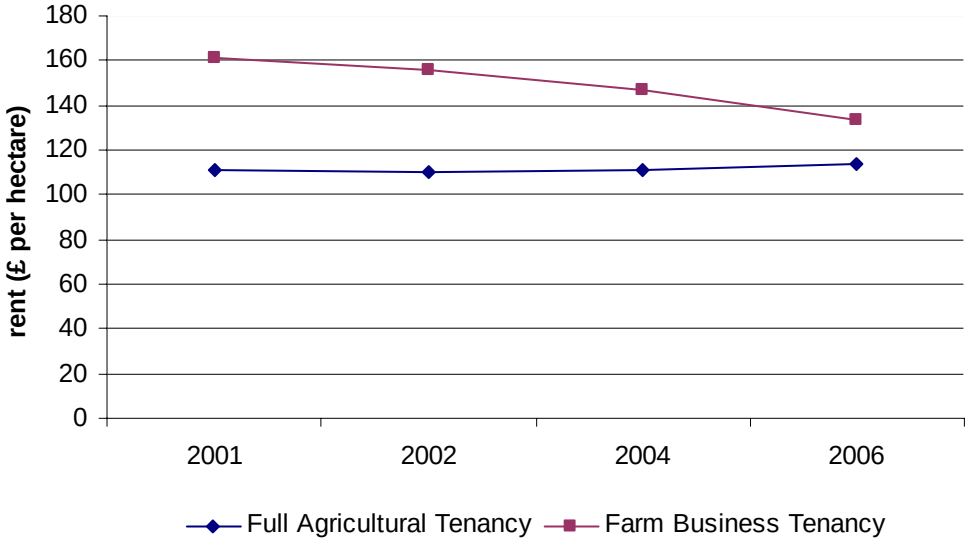
6.2 Tenancies and businesses on the Crown Estate

The National Picture: Tenancy Law – 1986 and 1995 Acts

The majority of The Crown Estates' agricultural land is let on tenancies, either Full Agricultural Tenancies (FATs) under the traditional Agricultural Holdings Act 1986 or Farm Business Tenancies (FBTs) under its successor, the Agricultural Tenancies Act 1985. FBTs were intended to make more land available for renting, to encourage new entrants to farming and to create flexibility in landlord tenant arrangements. Reflecting changes in the rental market for agricultural land, FBTs discontinued the principle of succession in new tenancy agreements and allowed greater opportunity for negotiation of terms between landlord and tenant. In 2006, 27 per cent of all agricultural land in England was let on FBTs, the remainder was let on FATs and other less formal arrangements.

Over time, rents for land on FBTs and FATs have tended to converge as shown from survey data reproduced in Figure 6.3.

Figure 6.3: Average Rents Paid Under Farm Business Tenancies and Full Agricultural Tenancies in England, All Farm Types, 2001 to 2006



Source: Defra Tenanted Land Survey 2006

Agricultural Tenancies and The Crown Estate

Overall, within The Crown Estate, at March 2007, some 12 years after their introduction, 27 per cent (by area) of the Agricultural Estates were let under FBTs contributing 33 per cent of the rent. This was consistent with the national situation. The Crown Estate's agents managed the letting of farms to progressively increase the area of land let by means of FBTs through restructuring of existing tenancies and through establishment of new tenancies.

However this process features a certain inertia, and on some individual estates FBTs account for less than ten per cent of land area. Evidence of this inertia is apparent from The Crown Estates' own inventory as shown in Table 6.3 below.

Table 6.3: Farm Business Tenancies (FBTs) as Per Cent of Agricultural Land Area, Unweighted

Agricultural Land Class	I	II	III	IV
Estates in group (number)	3	9	16	2
All Estates	44	27	40	50
Estates < 100% FBT	17	27	32	50

This rather crude analysis shows that the uptake of FBT arrangements has been greater on the poorer grade IV land than on land of better quality. The Crown Estates that are entirely let on FBT arrangements are likely to include recently acquired land so the final row in table 6.3 shows the case of the generally longer established estates that have a mix of FBT and FAT arrangements. These demonstrate a lower uptake of FBT arrangements suggesting that existing tenants with FATs on land of high agricultural potential may have been reluctant to transfer to an FBT arrangement even though this will sometimes have provided the opportunity to farm a greater area of land.

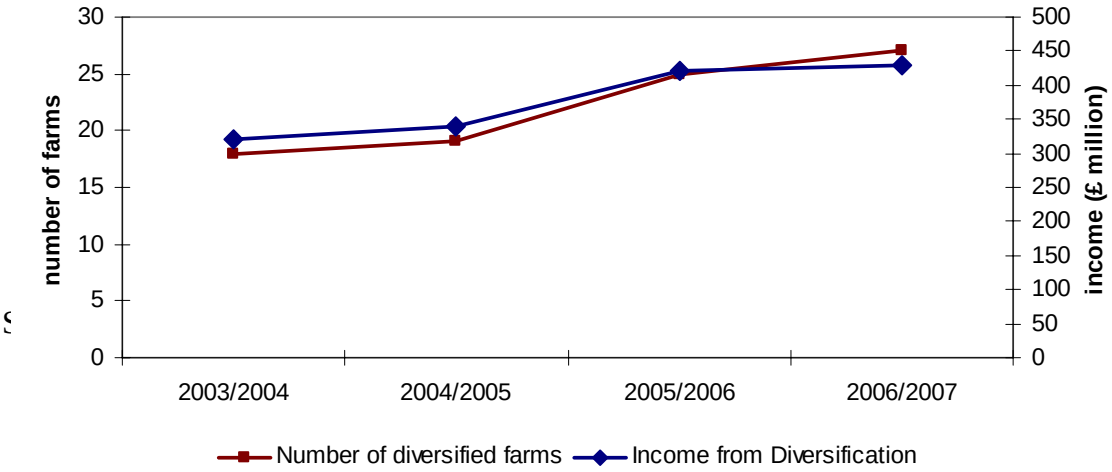
Alongside changes to agricultural tenancies, The Crown Estate reports a trend of letting farm cottages and farmhouses on Assured Shorthold tenancies and not as part of a holding. This is typical of industry practice and fits alongside the progression from FATs to FBTs.

Recent Changes To Tenancy Legislation

In the early 2000s, reflecting the increased economic importance of agri-environment and diversification activity alongside traditional agricultural activity within farm businesses, Defra engaged the Tenancy Reform Industry Group (TRIG) to resolve difficulties with these matters that had arisen between landlords and tenants.

The importance of diversification activity to farm businesses, and recent expansion of diversification activity, is quantified in Figure 6.4

Figure 6.4: Incidence in Diversification Activity and Income from Diversification, 2003/2004 to 2006/2007



The outcomes of the work carried out by TRIG are set out in the boxes 6.1 and 6.2 and below.

Box 6.1

Code of Good Practice for Agri-environment Schemes and Diversification Projects Within Agricultural Tenancies

The Code was devised by the Tenancy Reform Industry Group for use from 2005. It provides a framework to allow the landlords and tenants to agree terms for activities outside the strict definition of agriculture, and therefore not clearly defined in tenancy legislation.

Box 6.2

Regulatory Reform (Agricultural Tenancies) (England and Wales) Order 2006

This new legislation applies in England and Wales from October 2006 and is intended to:

- Encourage diversification by tenant farmers
- Maintain and improve viability of tenant farms
- Allow restructuring of holdings without jeopardising valuable rights
- Improve flexibility in the tenanted sector
- Maintain a balance between landlord and tenant interests

Eligibility for statutory succession to an Agricultural Holdings Act 1986 tenancy – 'the livelihood test'

Following recommendations by the Tenancy Reform Industry Group, the Order permits a successor to a tenancy to count earnings from diversification towards 'the livelihood test', with the landlord's agreement, in determining eligibility for succession. Previously, it was necessary for the potential successor to show that agriculture was the principal source of livelihood.

Introduction of a three year rent review cycle
The landlord or tenant has the right to a rent review after three years from the start of the tenancy or from the last rent review, even if there have been changes to the terms of the tenancy. This change was necessary because it removed a deterrent to making structural change of let holdings.

Changes to the Agricultural Tenancies Act 1995
Substantive changes to the legislation include the opportunity for the landlord and tenant to agree an upper limit on the value of compensation that a landlord is required to pay to the tenant for improvements at the end of the tenancy. Also, the landlord and tenant can agree to contract out from default rent review provisions.

The legislative changes described above created new opportunities for both new and existing tenants. Paradoxically, the changes provide opportunity within both larger and smaller holdings.

Larger farms are more likely to have surplus assets that can be turned to use within a diversified enterprise. These assets include traditional farm buildings that are too small to accommodate modern machinery and sometimes whole farm yards following consolidation of agricultural operations onto fewer sites. Depending on the tenancy terms, large let farms may have residential property that that was previously needed to accommodate larger numbers of farm staff The Farm Business Survey reveals that large Cereals farms often have the type of diversification enterprises that makes significant use of property assets such as redundant farm and residential buildings.

For smaller farms, diversification can provide the opportunity for a farmer to derive a full time living from an area of land that is too small to support a household from agriculture alone. For this reason, the very smallest farms often receive disproportionately high levels of income from non-agricultural activity that often has a high requirement for labour. This includes consultancy and workshop based activities.

The developments in tenancy legislation at very least enable the landlord to share in new sources of revenue. But the changes also provide the opportunity for closer cooperation between landlord and tenant.

The Crown Estate as Landlords

In this section, we consider the particular characteristics of institutional landlords, like The Crown Estate, as well as the circumstances of their tenants.

Public institutions are able to take a long-term view in relation to investment decisions. This is demonstrated by activities of The Crown Estate and anecdotal evidence suggests that this is also recognised by the agricultural community.

Social interactions between landlord and tenant can remain important in some circumstances. The activity of renting a farm from a public institution removes the possibility of a traditional 'social hierarchy' between the two parties acting as a constraint on farm developments and potentially leading to a more business-like working relationship.

On let farms generally, Agricultural Holdings Act tenancies have protected redundant agricultural buildings and other assets from sale or conversion and these are currently available for appropriate exploitation. It is likely that this is the situation within The Crown Estate. This situation differs from some owner-occupied farms on which divestment of assets has already been taken as an attractive solution to short-term financial problems.

In its Values and Corporate Social Responsibility statement, The Crown Estate demonstrates engagements with tenants beyond those set out in legislation or those observed more widely in the UK agricultural industry. For example, 'farm tenants are being encouraged to sign up to the Linking Environment and Farming (LEAF) audit'.

Characteristics of Institutional Tenants

Analysis of farm income data by tenancy status reveals important cultural as well as economic differences between owner-occupiers, mixed tenure and wholly tenanted businesses. As average farm sizes have increased, owner occupied businesses have taken on tenancies and wholly rented businesses have made purchases of land. As a result, the majority of farm businesses have mixed tenure and the trend is towards fewer owner occupied or wholly rented full time farms.

The Tables below (6.4 and 6.5) draw on recent research and compare the land holding arrangements of tenants according to the type of landowner in a survey of tenant farmers conducted in 2005. One category relates to 'Institution (including The Crown Estate)' and further categories include 'local authority' and 'financial institution'. The first table considers the range of landowner types that individual tenant farmers deal with. Each respondent was asked to nominate the types of landlord from whom they rented land (referred to as Landlord 1, 2 and 3). Please note that care is needed when interpreting data based on relatively low sample sizes.

Table 6.4: Number of landlords of each type

Landowner type		Landowner 1	Landowner 2	Landowner 3	Total
Private Owner	Count	89	58	33	**180**
	Percent	35.7	61.1	71.7	**46.2**
Landed Estate	Count	63	9	0	**72**
	Percent	25.3	9.5		**18.5**
Institution (incl. Crown)	Count	**36**	**10**	**4**	**50**
	Percent	**14.5**	**10.5**	**8.7**	**12.8**
Other	Count	25	9	5	**39**
	Percent	10.0	9.5	10.9	**10.0**
Local Authority	Count	19	2	2	**23**
	Percent	7.6	2.1	4.4	**5.9**
Family member	Count	15	7	2	**24**
	Percent	6.0	7.4	4.4	**6.2**
Financial Institution	Count	2	0	0	**2**
	Percent	0.8			**0.5**
Totals		249	95	46	**390**

Source: Table 5.8, Research into the Potential Impacts of CAP Reform on the Diversification Activities of Tenant Farmers in England – Baseline Study
Ilbery, Maye, Watts and Holloway, 2006

The table above suggests that it is quite common for tenants of institutions such as The Crown Estate to rent land from more than one landlord. Within the survey, there were no specific instructions about how landlords should be ranked but it is very possible that respondents placed their main landlord in the position of Landlord 1 and so on. The table implies that tenancies with landed estates are often exclusive to that estate whereas tenancies with private owners tend to operate alongside other tenancy arrangements. Tenancies with institutions such as The Crown Estate tend to show a mix of both of these characteristics. The second table (6.5) below takes a subset of tenant farmers with only one landowner and shows the split of these businesses between wholly tenanted, mainly tenanted (up to 75 per cent) and partly tenanted. Of the 36 tenancy arrangements with institutions, about half related to a sole tenancy agreement with one landlord. In the majority of cases, these related to wholly tenanted farms.

Table 6.5: Number of landlords of each type for respondents who rent from one owner, by tenure type (n=159)

Landowner type	Total	Wholly tenanted	Mainly (75-99%)	Partly (10-74%)
Private Owner	52	20	7	25
Landed Estate	45	26	7	12
Other	20	7	3	10
Institution (incl. Crown)	**17**	**10**	**4**	**3**
Local Authority	12	7	1	4
Family member	11	2	0	9
Financial Institution	2	1	1	0
Total	159	73	23	63

Source: Table 5.9, Research into the Potential Impacts of CAP Reform on the Diversification Activities of Tenant Farmers in England – Baseline Study
Ilbery, Maye, Watts and Holloway, 2006

At this point, it is worth considering some observed characteristics of the more profitable arable farms from the Farm Business Survey. These include:

-Mixed tenure – not owner occupied or wholly tenanted
-More diversified (especially observed in years of low commodity prices)
-Higher crop sales price
-Higher yield
-Lower variable cost expenditure
-Use contactors to carry out selected activities
-Use technical advice
-Not always the largest farms (typically below average size)

These characteristics are likely to reflect the type of good business planning and attention to detail in management that is necessary in a sustainable farming business. There is no direct relationship between these individual characteristics and farm profitability. For example, the use of technical advice alone will not make a farm profitable. However, they indicate the potential benefits to landlords of working with forward-looking businesses that are generally expanding and diversifying rather than keeping the status quo.

Possible Policies or Actions for The Crown Estate – Rental Arrangements

The most beneficial policies of The Crown Estate are likely to be those that create a business environment that allows tenants to build profitable sustainable businesses that meet the aims of The Crown Estate, with minimal constraints to entrepreneurial activity. A general observation from the research described above is that it is more beneficial to recruit the most forward looking and capable farmers rather than seek tenants for reasons of loyalty to the landlord. The increasing adoption of different tenancy and contracting arrangements in order to assemble sufficient areas of land for profitable farm businesses contrasts with the traditional relationship between a single landlord and a single tenant. But it is clearly important for tenants to have this flexibility in developing dynamic and efficient businesses. An issue for The Crown

Estate is to consider how this flexibility can be combined with a continued stewardship of land and environmental resources. In the end, this may well depend on the personal qualities and commitments of the people involved rather than the technical nature of the legal relationship.

In a possible further development, and considering the potential value of diversified activity, The Crown Estate has the scale and the resources to consider new mechanisms to select tenants with business potential but not necessarily a long track record. At the extreme, this might be achieved if The Crown Estate took on the role of a venture capital provider.

In some cases, the aims, of The Crown Estate may be achieved by using land for purposes other than agriculture. More flexible farm business tenancy legislation may allow environmental land uses that fall outside the definition of agriculture.

Possible policies or actions for The Crown Estate – Diversification

As a first stage towards sharing the financial benefits of farm diversification, a resource driven exercise is suggested. It would be desirable to identify and quantify the resources available for diversification. For example, buildings that are no longer quantified on insurance schedules because they have no agricultural or heritage value may now provide facilities for diversification. Characteristics that have no agricultural value can also be quantified and include qualities such as proximity to road or rail networks as compared with more remote and depopulated locations. We suggest that resources are reviewed, in an exercise engaging as many stakeholders as possible (managing agents, tenants, neighbouring residents, existing customers). As previously noted, The Crown Estate holds property assets of a type that have typically been sold by other landowners.

Prior to recent legislative changes, entrepreneurial diversifying farmers were almost obliged to purchase land or lease land on non-agricultural arrangements in order to diversify. The challenge for forward looking landowners is now to welcome these farmers back and create incentives for them to build diversified farming businesses within Farm Business Tenancies.

Some diversification requires investment that is beyond the scale or timescale of an individual tenancy agreement. The Crown Estate is especially well placed to make longer-term investments of this type. A vineyard and winery are examples of the type of investment that extend beyond the usual term of new agricultural agreements.

Other diversification activities can include activities that necessarily include agriculture but extend into other markets. For example, an anaerobic digester involves agriculture for supply of feedstock and disposal of digestate, but potentially involves customers for electricity, heat and ROCs.

To summarise, the activities are to initially assess and quantify the opportunity for development of diversified agriculture on The Crown Estate. A remedial task, created by recent legislation that has failed to fully resolve the issues, is to establish the most appropriate conditions for farm diversification within the revised legislation. The

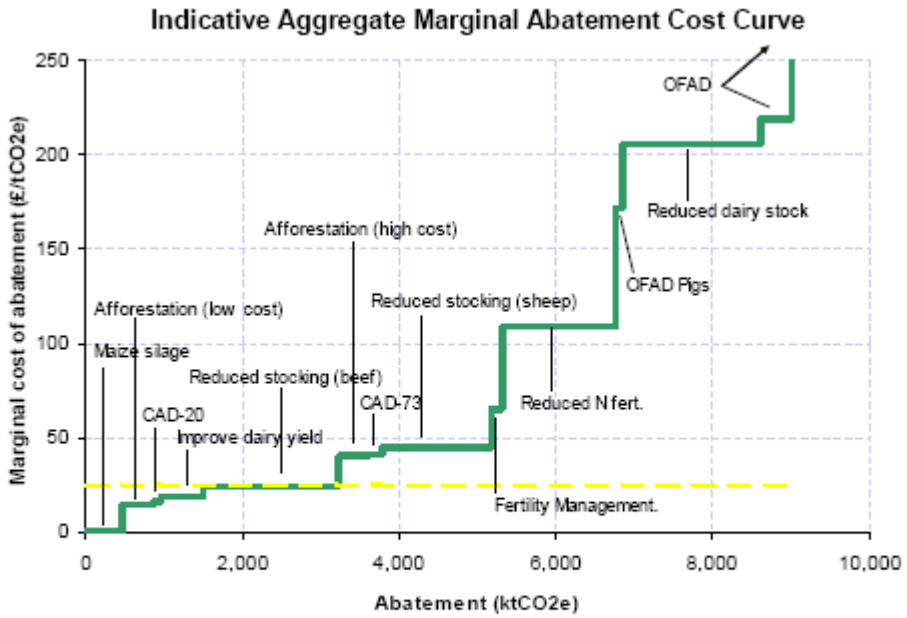
final stage is to identify the particular strengths of The Crown Estate that will create opportunities for successful diversification.

6.3 Implications of Climate Change

The costs of reducing emissions

The approaches that may be taken and the costs of reducing GHG emissions have already been discussed. Figure 6.5 summarises similar information in the form of a marginal abatement cost curve for agriculture. Some approaches have minimal cost , notably afforestation and reducing stocking rates in livestock production. In fact, where livestock production is not profitable, we may ask why there is any cost incurred at all. But beyond that, marginal costs of higher rates of mitigation rise substantially. This is of course a snapshot and over time we can expect that new technology and better application will tend to reduce the costs that are faced.

Figure 6.5: Cost of Reducing CO2 Emmission from Agriculture



Source: NERA modelling based on ADAS cost and abatement potential inputs and Defra holdings information.

Note: As discussed in the text, the MACC is sensitive to input assumptions and time-dependent market information.

NERA (2007)
Source: https://statistics.defra.gov.uk/esg/reports/ghgemissions/default.asp

The costs of adaptation

Costs of adaptation are notoriously difficult to quantify because of several complicating factors. One of these is the lack of a baseline for comparing the cost of adaptation or no adaptation: where does one draw the line? Additionally, one adaptation action may have ancillary benefits which make quantification difficult.

Furthermore, adaptation is more of a *process* than an *outcome*, and no state is ever fully adapted to climate change (the term "climate proof" is misleading). This is illustrated regularly by the damage that is still caused by flooding and droughts.

At present there are no real estimates of the costs of adaptation in many sectors, with the exception of the costs of "hard" adaptation options, such as coastal defences. In agriculture there are no systematic documented costs of adaptation. In any case, many of the adaptation actions discussed previously are management actions that can be incorporated into the general running of The Crown Estate without incurring specific costs.

Other adaptation strategies identified previously fall into the public realm, such as education, training and research. However this is an area where The Crown Estate as an organisation could contribute to the success of the individual businesses by providing information on likely future climate impacts in different regions, disseminating the latest research on adapting to climate change, and perhaps setting up support networks or even investigating insurance schemes.

Business opportunities

- *market gains in being low Carbon*

Whether The Crown Estate businesses implement carbon reduction strategies voluntarily or in response to regulations, there may be benefits to gain from promoting The Crown Estate as being a low Carbon producer. If there was an opportunity to differentiate The Crown Estate products and then market them as being low Carbon (or even Carbon neutral), particularly if this was done ahead of other producers, there could be a considerable competitive advantage to be gained. This would depend on whether reducing emissions from agriculture was mandatory or not, and on whether The Crown Estate could differentiate their products from others. The costs of reducing emissions voluntarily may of course be greater than any market gain, but it is an area that could be investigated.

- *efficiency/financial gains*

Many of the emission reduction strategies focus on more targeted use of inputs (particularly fertiliser), which may result in less wastage and hence reduce overall costs, providing yield is not affected.

- *Climatic opportunities and minimised damage*

A changing climate may also create opportunities for agriculture in The Crown Estate. Increased availability of CO_2, together with increased temperatures, may lead to an increase in crop suitability. This may mean that more productive crop varieties are able to be introduced, along with quicker maturing varieties in order to maximise yields.

Crop, forest and livestock productivity all have the potential to increase. Crop yield and biomass may increase. In order to take advantage of this, more productive varieties should be introduced, as well as quicker maturing varieties, to maximise yields. Energy crops, short rotation coppice and miscanthus could all be increased to take advantage of the increased availability of CO_2 and higher temperatures (however

bearing in mind other issues around energy crops). Crop productivity may also increase due to an increase in frost-free days and less frost damage.

Because of increased temperatures and improved growth conditions, greenhouse production costs may decrease. Less severe winters may mean reduced animal housing costs over winter (although animals may require more housing in summer to escape the heat). This could mean certain types of livestock farming could be extended to new areas (AEA Energy and Environment, 2007). Scotland in particular may benefit from the gradual changes in climate, and may be able to increase the range of production. However, extreme events are likely to be the earliest and most damaging manifestation of climate change, so it is important that producers do not become complacent and focus only on the possible benefits.

Adapting now rather than delaying action until more extreme events, or other climatic changes occur may lead to cost reductions in the longer term. For example, the costs of the 1995 summer drought to the agriculture industry have been estimated at a loss of £457 million due to reduced income and capital costs (Subak, 1997). Evidence suggests that those farmers who implemented adaptation and management changes at that time secured advantages over others (Defra, 2005).

Possibilities for GHG policy and carbon trading

Given the establishment of the European Emissions Trading Scheme for carbon coupled with the identification of agriculture as a significant source of GHG emissions, there is an immediate question as to whether such a trading scheme might be established in order to regulate emissions from agriculture. And if so, how might The Crown Estate be affected by it and how might it prepare for it? As should be clear, the regulation of GHGs from agriculture is not straightforward. They arise in several different forms, and primarily not as CO_2. They arise from a range of different processes and emissions are not typically directly or necessarily correlated with the volume of production. Farms are small businesses, spread over a large area and so the transactions costs of implementing and enforcing any policy are likely to be relatively large.

In terms of developing emissions trading, clearly something measurable and verifiable has to be identified as the item to be traded. There is an immediate problem in terms of agriculture's contribution towards international targets for GHG emission reductions in that many of the measures that could be used to reduce GHG emissions in agriculture would not be recognised by the methodologies currently used by the UK to report national emissions under international GHG accounting rules (NERA, 2007). In principle, the variation in circumstances and abatement costs amongst different farms types and locations would suggest the potential benefits of an incentive mechanism, such as emissions trading. But there is a risk that if misdirected, it could exacerbate the problems. For instance, if linked to livestock numbers it could cause a decline in types of production that generate less GHG per unit of output than other systems. But this is not to suggest that trading is not possible. It might for instance be based on some sort of certification scheme, where farms could opt to have an external assessor certify their level of emissions, and then the farm could sell units if it was below some standard.

Few new environmental policies are introduced in such a way as to immediately penalise polluters. Rather, in practice, there is almost invariably an initial phase where there is a voluntary, often subsidised, to initiate the approach, which only later imposes a penalty on excessive pollution. In this case, we may expect that agri-environment incentives might be used initially to develop systems and promote methods of GHG reduction, followed subsequently by a more regulatory approach. This suggests that there will be an optimal time at which to introduce changes: not too late by when penalties have been introduced, but also perhaps not too early before subsidies have been offered.

As has been noted, agriculture represents a major source of GHG emissions in New Zealand and the country has pledged to bring agricultural emissions into its Emissions Trading Scheme from 2013. From that date, direct emissions from stock (methane and nitrous oxide) will be included into the ETS. A free allocation of units (tradable units on the ETS) will be allocated to the agriculture sector in 2013. This allocation will be based on 90% of 2005 emission levels at 2013 through to 2018 then reducing to zero allocations at 2030. However, at this stage the mechanism by which the process will be operated has yet to be determined[33]. This experience will be valuable in illustrating how such an approach might operate.

6.4 Farming systems: diversification and change

The farm budgets suggest that businesses will not simply continue in the same ways over time, but rather will be under pressures to make changes to their farming systems.

Wider business opportunities for tenants might include:

- Specialist or niche agricultural enterprises
- Adding value to farm products
- Non-farm activities on farms
- Off-farm opportunities
-

The sorts of system changes available to farmers has recently been illustrated by Boatman, Dwyer and Ingram (2006). These represent the sorts of changes that all businesses will need to consider, whether they can the capacity to expand or the need to consolidate (Figures 6.6 – 6.8: immediately following).

[33] http://www.carbonfarming.org.nz/ets-agriculture.html

Figure 6.6: Possible system changes – lowland livestock

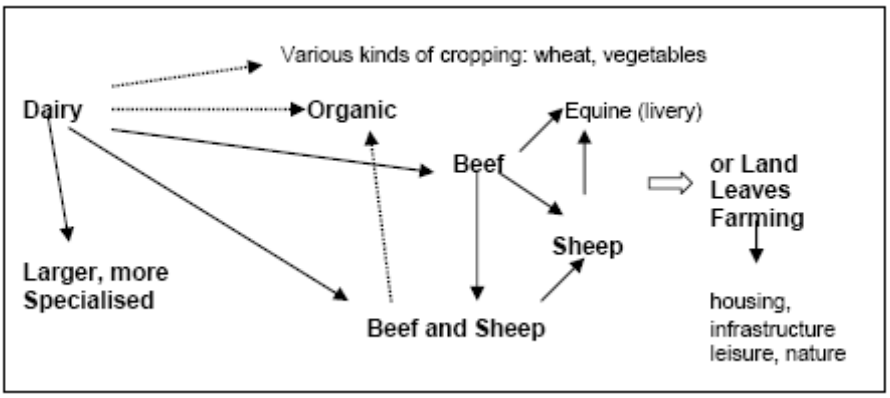


Figure 6.7: Possible system changes – LFA farms

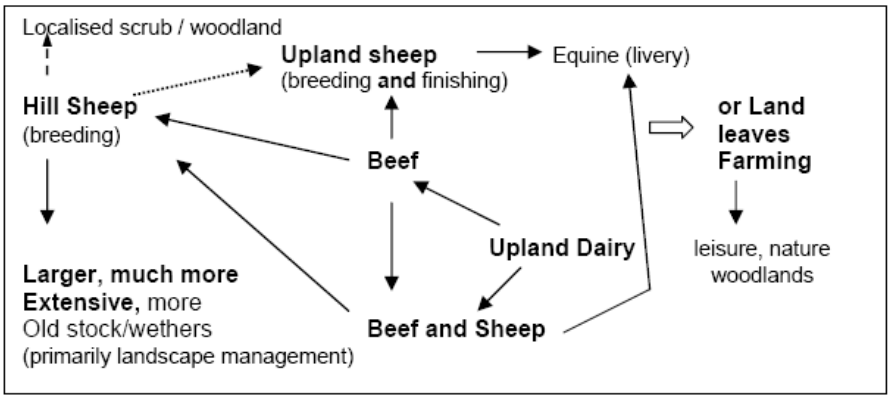
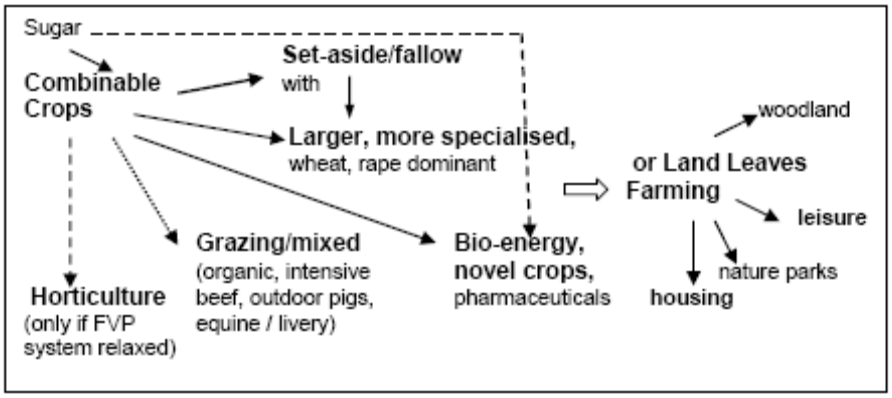


Figure 6.8: Possible system changes – arable and horticulture



Source: *OBS 04: The environmental implications of the 2003 CAP reforms in England*

Biofuels and biomass

Demand for biofuels, due to climate change pressures and higher oil prices, could remain a factor in demand for wheat for the foreseeable future - acting to maintain prices in a somewhat higher range than seen previously. ABF/BP/DuPont are constructing a plant at Immingham that produce around 300,000 tonnes of ethanol per annum (using around 1Mt of wheat from 2009). Cargill has commissioned a starch/ethanol plant that will use around 1Mt of wheat. These uses are likely to be sufficient to maintain a higher level of prices, and possibly add typical shipping costs to the UK price. There are plans for other plants but the outlook is somewhat uncertain as public sentiment could be turning against biofuels. The Environmental Audit Committee has concluded that "most first generation biofuels have a detrimental effect on the environment overall" (Environmental Audit Committee, 2008). There is thus some pressure to review the EU biofuels directive, and the prospects remain unclear. Nevertheless, it does seem likely that some level of biofuel production will be part of the mix of renewable energy sources that is developed.

The development of second generation second generation biofuels will make production potentially, to some degree at least, complementary to agricultural food production using by-products and waste as a feedstock.

Biomass heating, through combustion of short rotation coppice (usually Willow, *Salix viminalis*) wood chips or pellets or *Miscanthus* straw, is particularly efficient in terms of abating CO_2 emissions. It is thus very 'climate friendly'. Where tenants have a large requirement for heating, or could supply a steady source of demand (such as a large institution or district heating scheme) this may represent a practical and economically efficient way of reducing the carbon footprint.

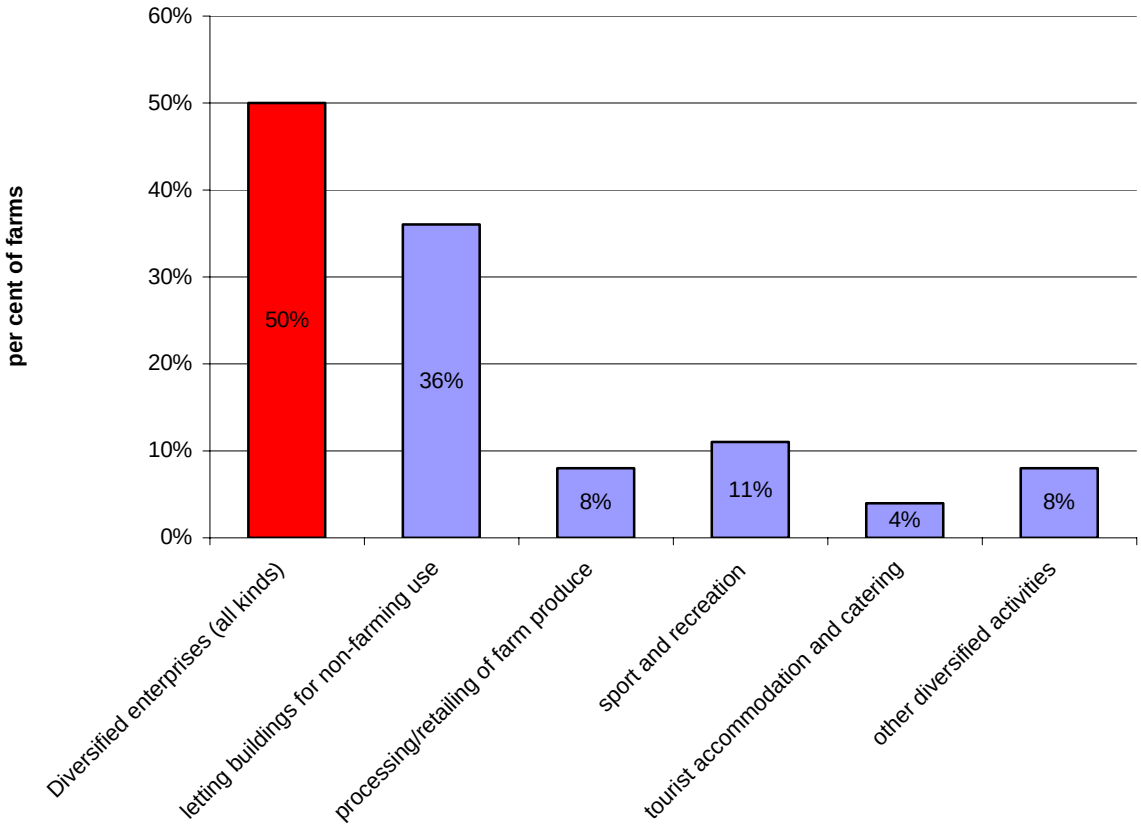
Diversification Activity Projections to 2028

Uptake

The farm budgets excluded diversification activity because the current and future opportunities are specific to the characteristics and resources of individual farms and do not fit well with farm types and regions.

Based on analysis of diversification from the FBS, Figure 6.9 shows the uptake of diversification activity on farms in England.

Figure 6.9: Uptake of Diversification Activity (per cent of farms), 2006/2007



Overall, 50 per cent of farms have diversification activity, grouped here within the categories of letting, adding value to farm produce, rural sport, tourism and a residual 'other' category. The 36 per cent of farms that let buildings for non-agricultural use were likely to have suitable buildings, often redundant agricultural buildings, and a sufficiently active local economy to create a market for let buildings. Similar arguments apply to all of the diversification activity shown. For all of the enterprise groups, similar conditions would apply. Agricultural contracting is excluded from this figure because it is included in the farm budgets above.

Only the 2006/2007 data are shown, but the uptake of diversification has changed little in the last few years.

Recent changes to tenancy legislation may create opportunities for a greater proportion of businesses, including tenants of The Crown Estate, to diversify.

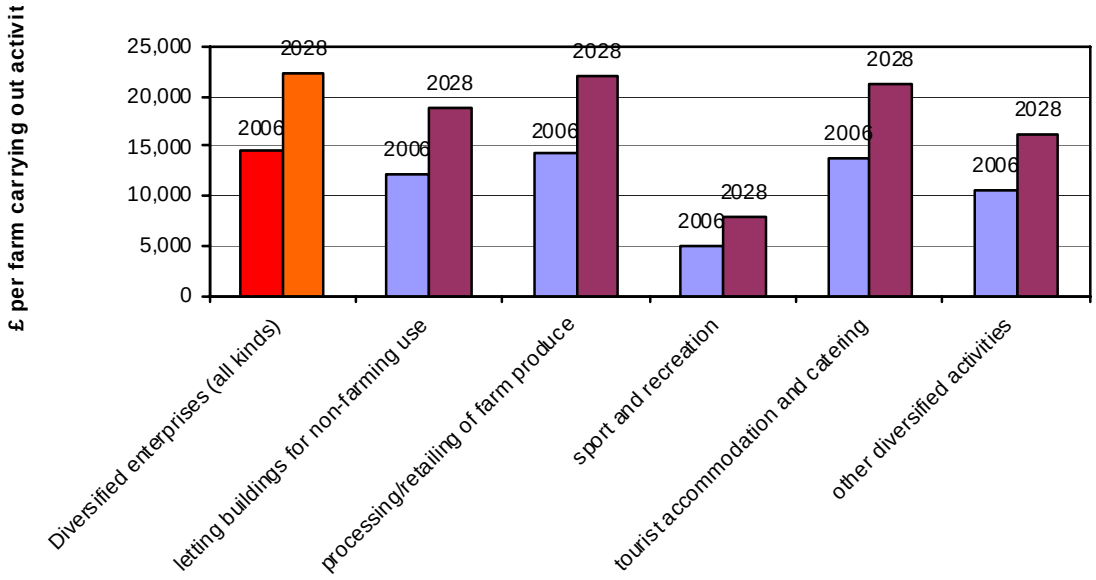
Farm Performance

Figure 6.10 shows, for farms carrying out diversified activities, the average output from diversification, by type of activity.

Alongside the 2006 results, we present projected 2028 values assuming that output increases at a constant rate. Since 2002, and in generally favourable economic conditions (positive economic growth and low interest rates), output from

diversification has increased by approximately two per cent per year. This is only an approximate indicator because there have been annual variations for diversification as a whole and within each enterprise type. The budgets do not build in the wide variations in output that could occur following a significant increase in machinery running costs. In many cases, land and labour costs are more important as inputs to diversified enterprises.

Figure 6.10 Output from Diversification (£ per farm carrying out the activity) 2006/2007



For each product or service, the output might generally be expected to track the wider market, but other factors will be important in determining changes in output. As an example, rental income could vary annually along with residential and commercial rents. However, some rural sites might have characteristics such as access, quiet or visual appeal allowing them to outperform the market or gain market share. The economic performance of each enterprise group will vary according to market, and so, for instance, tourism will be exposed to the prospects for UK rural tourism.

7. Roles and options for The Crown Estate

7.1 Opportunities and threats

Having set out the possible futures and their implications, it is appropriate to review the Threats and Opportunities that may arise. The main threats are associated with increased levels of competition for the productive activities on The Crown Estate and the possible constraints or increased production costs that may be imposed in order to meet social and environmental objectives. Against this, there will also be opportunities. Changes in markets and production methods create an opportunity for some producers to move faster and to be ahead of the game; a first mover advantage. They also offer advantages to producers who can identify new products or who can make themselves more competitive that the traditional producers. Table 7.1 suggests some threats and opportunities that may be associated with the changes that have been identified in this report.

Table 7.1: A Rural Estate (SW)OT

	Threats	**Opportunities**
Increased concerns for the environment and resource conservation	Constraints on use / Higher costs of nitrogen; phosphate;	Market access for cost effective first movers
Constraints on water availability	Increased irrigation costs	Collective provision of water supplies
Higher energy prices	Increased costs of high energy inputs	Development of lower energy systems Local production of imported commodities with higher transport costs (per unit value) Local tourism Renewable energy production (raw materials, wind, anaerobic) Peri-urban settlements (rather than in more rural areas) to reduce commuting costs
Climate change: adaptation	Increased climate variability and production risk	New production opportunities in modified climate
Climate change: mitigation and Carbon pricing	Constraints /higher costs of GHG emitting activities	Carbon sequestration. Payments for mitigation (carbon trading)
Biosecurity and food safety*	Disease risk to domestic production	Local production under high security conditions to avoid risky imports

Biodiversity	Reduced funding available for agri-environment schemes. Shift in property rights – protection becomes a duty	Higher government priority generates opportunities
Trade policy	Vulnerability to reduced tariffs on imported products: Beef Poultry Sugar	Opportunities for exports? Increase quality and differentiate local production
CAP reform	Loss of Single Farm Payment	Opportunities from Pillar 2 for new projects on the Estate
Retail competition	Farmers margins squeezed by large purchasers	Collective action on estate Third way between supermarkets and farmers' markets?
GMOs	Environmental hazard Public rejection	More cost-effective production Reduced vulnerability to climatic and other threats
Health and dietary concerns – better informed consumers	Reduced demand for high fat, red meat?	Fruit and vegetable production Better labelling (eg carbon footprint) supports product differentiation

* Imported foods accounted for 80% of the food alerts that the UK submitted to the EU in 2006 p.73 in 'Food Matters' 2008

Many of these threats and opportunities will first impact on the tenants on the Estate rather than on the Estate itself, although there is always the potential for a subsequent impact on levels of rent. However, The Crown Estate can become involved in a variety of ways. It can:

- take direct action on the land that it manages in hand
- it can provide leadership and information to support change and innovation
- it can work with tenants either through rental agreements or by joint investment or action
- it can support co-ordinated or collective action amongst its tenants
- it can seek to influence government and the policy environment.

7.2 The resilience of agricultural businesses

Farm businesses need to develop their resilience in the face of greater exposure to the volatilities of world markets and reduced level of support under agricultural policy. They also face a more uncertain future against the uncertainties associated with climate change. There may be opportunities for the Estate to work with tenants in order to build up the resilience of their businesses over time. Clearly the Estate will seek to build a community of able and highly motivated tenants. As we have noted, this may be supported by a flexible approach by the Estate in terms of what it will allow its tenants to do. Education, training and sharing information will also be important.

We are experiencing a period of substantial dis-integration in terms of the ways in which agricultural businesses are owned and operated, especially in terms of the means by which they gain access to land. Farm businesses are not simply mixed tenure but gain access to land and resources by a wide variety of arrangements. Businesses can achieve economies of scale by specialising in particular types of production across several different holdings. Businesses involve a mix of agricultural and non-agricultural enterprises. This flexibility and diversification will be increasingly important, and complex, and the Estate will need to do what it can to encourage it in appropriate circumstances. At the same time, the separation of long-term land occupation from its use and management threatens to undermine the traditional land occupier's sense of environmental stewardship and this is an issue for consideration.

Farming also faces threats arising from climate change and the environment. In this respect, there may be a role for the Estate to support investments aimed at reducing the risks of natural disasters, such as flooding, or from environmental stress, such as limits imposed on water for agricultural uses. There is a need to anticipate the particular threats to particular types of businesses on the Estate both directly from climate change and indirectly from policies that will require then to mitigate GHG emissions. This should be based on a comprehensive analysis of GHG emissions and stocks. Generally, we assume that adaptation will be better earlier than later, but there is the issue as to whether Government may offer financial support at some stage; so there may be a penalty in acting too early. Building resilience may be something that can be done better collectively rather than individually by tenants. We return to the issue in considering the potential for co-ordinated actions on the estate later in this section.

7.3 Land management, land use and ecosystem services

There will be changing and probably increasing pressures on the social values and implications of land uses and The Crown Estate will be affected by them. We have identified a variety of ways in which land use and management will be called upon in addressing climate and environmental impacts. Changes in land use and in management have the potential to make a significant contribution:

- The Environment Agency has identified river basins at risk of failing to meet the water quality standards under the Water Framework Directive as a consequence of diffuse source pollution from agriculture. This may require changes in agricultural systems and intensity.
- A number of areas face significant flood risk which will be exacerbated as a consequence of climate change. Land may be put into flood mitigation schemes in order to reduce the risks faced by other areas.
- Some land areas, especially with peat soils, that are at risk from high levels of carbon emissions and others have the potential for land use change to achieve carbon sequestration. It has been suggested that the greatest gains in terms of CO_2e emission reductions are likely to come from taking cropping organic soils out of production (Laurence Gould and CRED, 2008).
- The Crown Estate already has a target to meet the English Nature target to bring 95% of Sites of Special Scientific Interest (SSSIs) under its direct management in England to be in favourable condition by 2010. But this and the achievement

on other SSSIs may well depend on the management of the wider countryside rather then just the SSSI itself.

- Biodiversity can be protected and enhanced by creating networks of habitats and buffer areas around the most sensitive sites.

Land use changes in these contexts have the potential to enhance the provision of ecosystem services and increase the resilience of ecosystems in a variety of ways, such as in terms of adapting to climate change and in enhancing the capacity of biodiversity to withstand shocks especially associated with climate change. Most of these issues relate particularly to specific sites and the question arises as to what extent these sites overlap and, following from this, whether there are certain critical areas of land where land use change could make a major contribution towards the provision of a range of ecosystem services. This may be achieved by planting trees, taking land out of intensive production or extensifying land uses. The Crown Estate has already undertaken work on many of these issues and so it may be possible to overlay the information in order to identify locations where there are complementary opportunities. These areas should be looked at against the existing mosaic of forestry, designated conservation sites and areas of high landscape value. But more work may be needed before this is possible. Where the land is held in hand, the Estate could make direct changes in land use to achieve these objectives. Where it is let, it may be possible to come to some arrangement with the tenant. The changes of land use required would probably incur some reduction in financial returns, but it would seem probable, or at least it should be the case, that such areas identified in this way would be eligible for government funding, particularly through an agri-environment scheme. Another approach might be to link this type of land use change, perhaps the reduction of flood risk, with land development opportunities so that the promotion of ecosystems services might be funded through some form of planning gain agreement. In the absence of such compensation, and where there are clear ecosystem benefits to be gained, The Estate may see implementation of the changes as a way in which it can demonstrate its commitment to land stewardship and as an example to others even if it involves some financial loss.

The land use changes implied should represent a long term goal. Some change may be possible in the short term, especially where it is supported by agri-environment policy, forestry grants or planning gain, but in other contexts land use change can be disruptive and may even threaten the viability of some holdings. There may be opportunities for investments in new buildings and facilities that could enable tenants to expand their businesses in other ways in order to compensate for a loss of agricultural land. At the same time, the development of environmental quality in local areas may open out new opportunities for recreational or tourism activities as well as public access. Thus the identification of critical areas and land use changes should be used to inform long term decisions about re-letting land, afforestation or taking land in hand.

7.4 Collective initiatives by businesses on The Crown Estate

There will be circumstances when tenants can benefit from acting collectively rather than individually and the Estate may have a role to play in identifying such opportunities and facilitating action. It will, of course, always be a question as to

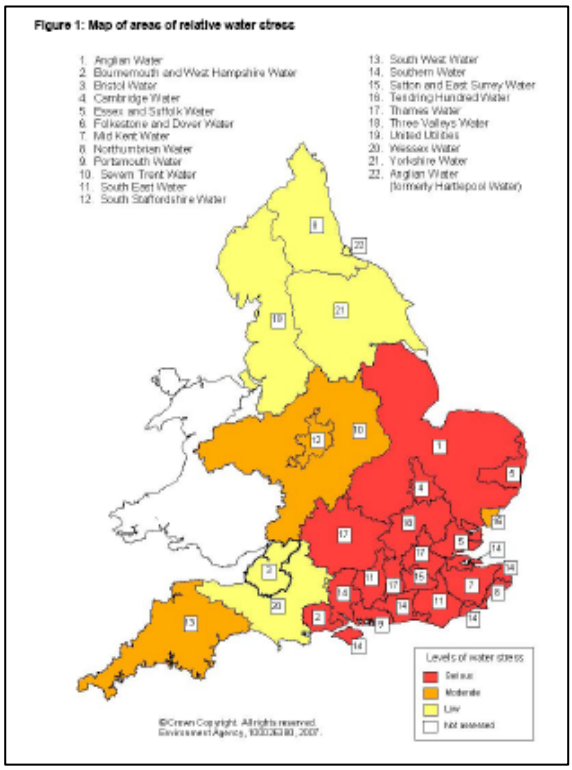
whether opportunities should be restricted to tenants and exclude other farmers. A judgement probably turns on which approach generates better outcomes for the Estate and more generally socially.

There are various issues that might be addressed in this way, such as in terms of water management, renewable energy and waste management, collective marketing or biodiversity management. There could be opportunities for tenants and The Crown Estate to work together to develop complementary tourism enterprises within local areas. Thus for instance there could be opportunities for the co-ordinated development of tourism enterprises perhaps based on forest recreation or farm-based activities, alongside farm-based accommodation. The same sorts of argument would apply too to more conventional farming issues such as machinery sharing or group selling of commodities. We briefly explore three issues as a way of illustrating the issues involved: water supply, anaerobic digestion and a quality mark and marketing

Water supply

Addressing environmental objectives in a cost-effective way will often require a significant scale of operation that may be beyond the scope of individual farmers. Figure 7.1 shows the areas of relative water stress and a number of estates are located within these areas. This suggests that addressing problems of water stress will be a significant challenge to businesses on The Crown Estate.

Figure 7.1: Areas of relative water stress



http://www.environment-agency.gov.uk/
commondata/acrobat/finalclassification_1935752.pdf

The issue here is whether The Estate can make an impact, either by becoming directly involved or by promoting co-ordinated actions amongst the tenants. There may well

be benefits to be gained by sharing information about the technical options for maximising the efficiency of water use. There may also be possibilities by which collective actions can enhance the quantity of water resources available on the Estate, such as by the construction of reservoirs. If this has not been studied, it may be something for consideration.

Anaerobic Digestion

One topical issue could be the introduction of anaerobic digestion for groups of farms on The Crown Estate. Anaerobic digestion (AD) has the potential to provide renewable energy, mitigate methane emissions from agriculture and divert food waste from landfill[34]. For these reasons, the technology contributes to the UK government climate change and wider environmental objectives whilst potentially providing an economic opportunity for some rural businesses.

Box 7.1: Anaerobic Digestion Explained

Anaerobic Digestion is a process that can be used commercially to convert organic matter to a mixture of gases that can feed a generator to produce electricity. The process is carried out in a closed vessel and best results are achieved when an appropriate ratio of carbon to nitrogen is available in the feedstock. On farm-based units, this can include livestock manure and slurry, food waste, glycerol (a biproduct of biodiesel production) and potentially crops grown for the purpose. Revenue is available from the sale of electricity, renewable obligation certificates (ROCS currently valued at about £44 per MWh[35]), gate fees for receipt of food waste and from the sale of heat in community heating schemes. Although there are handling costs associated with disposal of digestate, this material can provide nutrients reducing the requirement for purchased fertiliser.

Existing commercial plants suggest that about 1.1MW can be generated from around 40 thousand tonnes of feedstock[36]. Plant output is usually maintained by operating a batch system to introduce material to the digester and to remove digestate.

The potentially different sources of organic matter and the range of outputs determine that economics of anaerobic digestion are specific to each individual application. The economics are also influenced by transport costs associated with input of material, any growing costs of dedicated crop feedstocks, the prevailing market for electricity and ROCs. Full consideration of the integrated approach is necessary, as anaerobic digestion is only a third as efficient as mass burn and only one fifth as efficient as gasification[37].

The science of anaerobic digestion is well researched and plant is now commercially available (there are now some 3000 plants in Germany, and a number of installers

[34] Working Paper 3, UK Biomass Strategy 2007, Agriculture and Environment Team, Defra, May 2007, www.defra.gov.uk
[35] UK Biomass Strategy 2007, Agriculture and Environment Team, Defra, May 2007, www.defra.gov.uk
[36] Bedfordia Farms Ltd
[37] Waste Research Station, Cardiff University, www.wasteresearch.co.uk

already in the UK). Uptake in the UK includes installations by water companies to treat sewage.

There has been considerable enthusiasm for AD[38], but implementation is not straightforward. Aside from the economic and technical considerations, new biogas plants require licensing according to the nature of feedstock used and they require planning permission in a process that will consider transport of materials as well as release of odours (as AD plants release hydrogen sulphide). The experience of existing AD plant operators is that there is very little 'joined up' thinking among regulators and government facilitators of AD technology, and as a result, the transactions costs of starting up a new plant are currently disproportionately high. Also anecdotal reports on most recent developments in Germany, where there has been a major expansion based on government subsidy, suggests that not all AD is successful indicating that that care needs to be taken in determining the contexts within which the development takes place. If local livestock production is unable to provide sufficient feedstock, further material may have to be grown for the purpose taking land out of alternative uses and potentially undermining the economic gains from the plant. We may note that the Strategy Unit (2008) reported that over 60 new AD sites are being planned, many more in some regions than in others, indicating the need to ensure that there is a sufficient feedstock available within the locality.

The Crown Estate has relatively low exposure to intensive livestock production that can provide large quantities of feedstock at specific geographical locations. However, dairy farming is important to The Crown Estate and opportunities may arise in areas where a number of dairy units are present within a specific geographical area. It is possible that feedstocks from food waste will be available, but this is again dependent on geographical location. The Crown Estate is currently investigating the use of anaerobic digestion to generate electricity from plants using seaweed as the feedstock at Highland sites of its Marine Estate[39].

A quality mark?

Consumers are increasingly conscious of the quality of the food products that they consume and can be willing to pay a price premium in order to obtain higher quality products. But they need to be assured that any claims that are made for a product are genuine and reliable. Thus it is generally not sufficient for the producer to claim a particular quality, but rather the claim needs to be validated in some way or other. Generally, this involves an external and independent authority setting up a system under which production processes and product quality are required to meet a set standard and given some sort of certification where they do. If consumers have confidence in the reliability of the authority, they will give some credit to the claims. Such is the case with organic standards or the LEAF marque. The Strategy Unit (2008, p84) comments that "'Low Carbon' is set to become a source of comparative advantage for meat and dairy producers" and this may be a value that can be captured from consumers. The question is to what extent and on what basis will consumers be willing to pay a price premium for 'low carbon' products.

[38] For instance, Michael Chesshire's presentation to the Defra Conference 'Farming for the Future' London, November, 2007

[39] Seaweed, the new super power?
http://www.thecrownestate.co.uk/highlands_islands_update_winter_0708.pdf

Not all such certification is equally recognised and accepted or generates a significant price premium. And not all consumers are willing to pay more, especially in times of economic slowdown.

One possible innovation would be for The Crown Estate to certify products produced on its estate and to allow producers to use some marque on their products and in their advertising. This might give producers an edge in a competitive market and allow them to earn more from product sales. The Crown Estate has a strong image and could prove attractive to consumers. An obvious model here is the Duchy Originals brand established by HRH The Prince of Wales. However, the position for the Crown Estate is somewhat different. Duchy Originals is based on a strong organic vision and products are sourced from a variety of producers. It is not clear that The Crown Estate has, or should have, a particular view about the methods by which products are produced. Even if it did, it is difficult to imagine that all of the production from the Estate could attain this standard, so what would be the implications of products from the Estate that did not meet this standard? There would certainly be the issue as to who undertakes the product evaluation and validation and how, and a reputational risk to The Crown Estate should products be found by consumers not to reach the expected standard. A somewhat less ambitious approach might be to award some sort of certificate to products produced by tenants on the Estate that are seen to be of an outstanding quality, as and when such products are identified. There might perhaps be an annual competition, but without any obligation to award certificates if no products of sufficient quality were entered. This might give a modest boost to the product's sales although the selection of products for the award would inevitably be somewhat arbitrary and may lead to bad feeling.

More generally, it may be preferable to continue with the approach that has been used already, of encouraging tenants to take advantage of the schemes that are already in operation such as LEAF, organic, or the Carbon Reduction Label. Clearly The Crown Estate can encourage and support efforts to achieve the standard but would not have to establish a specific standard while at the same time producers will benefit from the wider recognition of a nationally recognised scheme.

7.5 The Crown Estate as leader and exemplar

Given the objective of The Crown Estate to providing leadership as a 'legacy for the future and an example to others', then The Estate should take on certain roles providing leadership to a wider community. One aspect of this will be achieving high rates of return, being recognised as an efficient organisation or actively managing a portfolio of assets. But in this section we concentrate more on the Corporate Social responsibility aspects.

Agri-environment schemes

Over time, with the introduction of agri-environment schemes, in some respects the state has taken on responsibility for providing environmental quality standards on agricultural land. In fact, there has been something of a movement in both directions. In some aspects, the duties of landholders have been raised in order to protect the environment. The duty to protect SSSIs or the introduction of Nitrate Vulnerable

Zones have established regulations to prevent actions that might harm the environment, without payment of compensation. On the other hand, payments in agri-environment schemes, especially through Entry Level Stewardship assert that landholders should be paid for the provision of public goods. In some aspects, in the past these are environmental standards that estate owners may have felt to be part of good stewardship. That assumption is clearly challenged when government proposes the payment for what are now described as public goods.

Now, in terms of the future direction for policy there is a real risk that higher commodity prices and pressures on EU and UK government public expenditures may threaten to undermine the gains that have been made through agri-environment schemes in recent years. Given The Crown Estate commitment to stewardship and good environmental management, this raises the question as to whether and in what way The Estate might act in place of government in order to secure and continue the advancement of rural conservation (especially landscape and biodiversity) benefits. In two of the scenarios, the government took little interest in environmental policy. There is thus clearly a significant risk of environmental damage without any public policy restraint, begging the question as to whether The Crown Estate should be adopting a more pro-environment position that the government is failing to provide.

In these circumstances, it could place conditions on tenancy agreements, select tenants on the basis of their own personal orientations towards the environment, or offer positive incentives for better environmental management. But if this takes place under conditions of relatively high commodity prices, this could have a high cost in terms of rental income foregone or direct expenditure, and this could be a significant deterrent. This cost could be lower to the extent to which long term arrangements had been put in place under conditions of lower agricultural returns, such as by means of binding covenants in agricultural tenancy agreements or by putting land of critical environmental quality into conservation rather than agricultural management. In principle, this might be held and managed in-hand or else passed over for management by a conservation organisation.

Simple visions for The Crown Estate

It would be possible for The Crown Estate to adopt a simple vision that can guide its approach in the future. This would be clear to the public and might send out a simple message that could symbolise the Estate's approach. It could identify an approach and offer leadership in that approach to the wider community. There are several possibilities, but they mostly have significant drawbacks.

An organic estate

One obvious possibility would be to aim to convert the estate to organic production. The Estate might set out a long term objective to increase the proportion of production undertaken using organic farming methods. It could encourage its tenants to convert and seek new tenants who plan to adopt organic farming. But clearly this would need to be based on a firm belief that organic farming represents the 'best' method that should be adopted more widely across the agricultural sector. This could be hard to sustain and would certainly be controversial. The Strategy Unit has commented that "The differences in environmental impacts between organic and conventional systems

are not at all clear cut and may be overridden by differences in individual farm practices (e.g. manure management)" (Strategy Unit, 2008, p17). In this context, it would be difficult and probably unwise to seek to persuade tenants to change their systems. This has to be primarily a judgement for the tenants who bear the main benefits and costs.

A GM free estate

The same sorts of problems would arise with attempts to maintain a GM-free estate as would be the case with seeking an organic estate. While GMOs are not generally authorised for use, then being GM-free is no great accolade. But were they to be authorised, then it could be hard to argue that tenants should not adopt them. Some degree of authorisation does seem probable by the year 2028. While concerns as to the risks of environmental impacts from the use of GMOs may be justified, the government has indicated its view that GM technology "is an additional tool that could provide significant benefits in the future" (HM Treasury, 2008, p36). There are likely to be particular situations where GMOs have potential value and it would be inappropriate for the Estate to rule out their use as a matter of principle when the Government has approved their use.

A carbon neutral estate

The target for a carbon neutral estate would be a rather different objective. It must be noted that we have no particular information as to whether or not this constitutes a feasible objective. The Crown Estate has already worked on aspects of it and it has set a target to achieve carbon neutrality for direct activities undertaken by the marine team and their managing agents. Few would argue with the importance and validity of the target and it would give flexibility in terms of what actions might be taken in order to achieve it. Clearly it can be possible to offset GHG emissions within one part of The Crown Estate by sequestration in another part. This might in principle be a source of inefficiency if the options for sequestration are restricted to those that can be achieved within The Crown Estate rather than adopting a global approach. On the other hand, it may have an emblematic purpose of demonstrating that The Crown Estate is fulfilling its responsibilities towards climate change mitigation. It may also give The Crown Estate confidence that it does indeed achieve its offsetting objective given that it retains control over the processes located on the Estate. Doubts over the validity and verifiability of other offset schemes may make this a good argument in favour of addressing the issue within The Crown Estate.

Community land manager

Such a vision need not be restricted to environmental issues. Many county councils have long-established agricultural estates whose primary purpose has been to provide opportunities for those wishing to enter farming to take a step on the farming ladder. However, in this respect they have not been notably successful; farmers have taken up smallholdings but have rarely moved off the estates onto larger tenancies and typically remain as county council tenants with rather restricted businesses. In practice the declining significance of agriculture in the economy means that it would be difficult to address social issues through the management of rural land other than in the more remote areas where some impacts may be possible. This is not, of course, to suggest that there cannot be situations where land use change and development can be advantageous for local economic development. Clearly this can be possible and may

be something The Crown Estate should be aware of, but it is unlikely to be adopted as a general land management principle.

7.6 The role of government policies

Various aspects of government policy can be helpful to the Estate in adjusting to the changes and responding to the opportunities that will emerge in the future.

Farming will operate in a considerably less stable environment than has been the experience over the past fifty years, both in terms of finance and climate. Government can explore whether this creates a role for some sort of insurance scheme that can support businesses facing especially difficult situations. Two sorts of arguments count against this. First that insurance should avoid giving decision makers incentives to take extra risks and second that such a scheme does not mutate into a commodity support scheme. There will though be a role for some sort of natural disaster relief for those whose businesses are damaged by events over which they could have no control and against which they are unable to protect themselves.

There may still be scope for changes in tenancy rules that facilitate flexibility and diversification of farm businesses and the assets associated with those businesses.

But in some circumstances it is possible for land managers to take actions to protect themselves against threats of natural disasters. Government could offer greater support for land management that increases the resilience of rural land and management against the uncertainties and volatilities associated with climate change. Often the cost of prevention will be less that the cost of the damage and of clearing up. It is important for government to create incentives for defensive actions to be taken rather than for them to be ignored until it is too late, in which case the burden is likely anyway to fall substantially on government. Government support for precautionary actions may well be cheaper in the long run.

There is also a need for government support for various approaches to land management to be joined up across the different types of public good that may be generated, whether they are in the form of flood protection, carbon sequestration landscape or biodiversity. These public goods are often joint products and land managers should be able to gain benefits for all of them when they manage land, even when the benefits are the responsibilities of different government departments and agencies. If the government pursues the logic of public money for public goods, then land managers should be able to farm their ecosystems services too.

Agriculture is a significant source of GHG emissions, but not primarily of CO_2. As a consequence, agriculture has had relatively little attention so far in the climate change debate, although this does seem to be changing now. One problem is that the reductions in GHG emissions are not recognised under international GHG accounting rules used for recording total emission levels. There is thus a need for a system for calculating GHG emissions that is accepted by the international policy community and in which consumers have confidence. This will both help to guide farmers in prioritising their actions in order to limit their GHG emissions in an effective way and help towards the development of policy measures and offsetting.

Agricultural systems will need to develop in ways that may depart from past experience. But there has been relatively little publicly funded research, development and extension towards the implementation of agricultural systems that are geared towards the emerging situation. It is important that this activity is substantially publicly funded, first because it generates public goods whose benefit is not readily captured by private businesses and second because it is often about using information to substitute for purchased physical inputs and private companies may see little return to be gained from investing in the development of these sorts of technologies.

8. Conclusions and recommendations

8.1 Conclusions and recommendations

Over the past couple of years we have seen major challenges to the widely accepted expectations for agriculture and rural land use. From an expectation of continuing decline in prices, low profits in farming and of the need for policy to retain land in environmentally beneficial productive uses, current assumptions anticipate higher energy and commodity prices, global scarcity of food and renewed anxiety for securing food and energy supplies. So we need to ask whether the fundamentals of global demand and supply have indeed altered irreversibly or whether we may return to the past trend. Recall that only twenty years ago in the 1980s there was a fervent debate as to how we might deal with the supposed problem of 'surpluses' of agricultural land. The likelihood is that the future will not be like the past, but perhaps not quite so different as may be feared. The current economic recession is certainly delaying and probably masking the underlying, longer term prospects. We have generally forgotten what a large proportion of income was spent on securing food in the past and have come to expect that it should take only a very small proportion of our income. This can not necessarily be sustained in the future. Commodity prices may be higher, but not necessarily as high as they have been in the more distant past. Farmers will be more exposed to an unstable global market, but some elements of agricultural policy seem likely to persist, even if they are more targeted and require more specific actions in order to become eligible for payment.

Climate change must be considered in any review of future options and threats. Over the period under consideration, the direct impact of climate change may not be very great, although there are some concerns that the change is progressing much faster than has been predicted in the climate change models with potentially more dramatic consequences. The main impacts on the Estate over the period under consideration will be associated with policies that require all activities to reduce their emissions of GHGs and the potentially less stable climate in which extreme events become more frequent. Farms will need to become more climate resilient and to develop lower GHG agricultural systems.

Our scenarios have highlighted a range of possibilities. While none represents a prediction of the future they give a framework for exploring the implications of alternative states of affairs. Farm businesses will be affected in different ways, depending on their production types and their exposure to policies targeted to reduced GHG emissions. They will also perform differently according to the skills and abilities of their managers in identifying and responding to the changes taking place.

The challenge facing The Crown Estate is to respond to a future that is likely to seek higher levels of agricultural production, produced by low carbon systems in a less stable financial and climatic environment, while at the same time supporting biodiversity and achieving higher standards of water quality. This will require new approaches but the changes will be evolutionary rather the revolutionary.

The Crown Estate can make a valuable contribution by assembling and sharing information, stimulating and supporting initiatives, by promoting co-ordination amongst its tenants and participating in joint ventures.

Government policy has long played an important role in guiding rural land uses. The present position has been substantially influenced by the sixty years of agricultural support since the Second World War. The policy has now changed considerably, but this too will need to continue to evolve in response to the challenges faced. In some respects this almost certainly implies a shift back towards a greater attention to the importance of agricultural production in research and development, but this needs to be set in the context of the requirement for low carbon systems and support for the provision of ecosystem services.

The study has operated at a broad scale without careful attention to the details of The Crown Estate and its tenants. Nevertheless, we offer some suggestions as a basis for discussion amongst those who have better information.

- It may be helpful to undertake a survey of resources available for diversification and share information about the prospects and opportunities that they represent.
- It could be interesting to overlay maps of ecosystems services potential, especially for flood protection, areas of high carbon in soils, areas of high biodiversity values and landscapes, areas where semi-natural areas have the potential to be connected into networks in order to search out critical areas and land uses for change
- The Estate should be constantly alert in looking for situations where collective action by groups of tenants, potentially in a joint venture with the Estate could generate socially valuable projects – anaerobic digesters, biomass energy production, Combined Heat and Power schemes, water conservation or flood protection.
- It may be valuable to undertake a survey of all GHG emissions and risks across the estate and abatement and protection options to identify cost effective approaches to GHG reduction at an Estate level. The variability of GHG emissions even between farms of the same general type suggests that this should be at a relatively detailed level. This can then help to anticipate the areas and activities on the Estate that will be most vulnerable to policies introduced to mitigate GHG emissions, and, when looked at together with information on the costs of options available to reduce emissions, to identify most cost-effective options.

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