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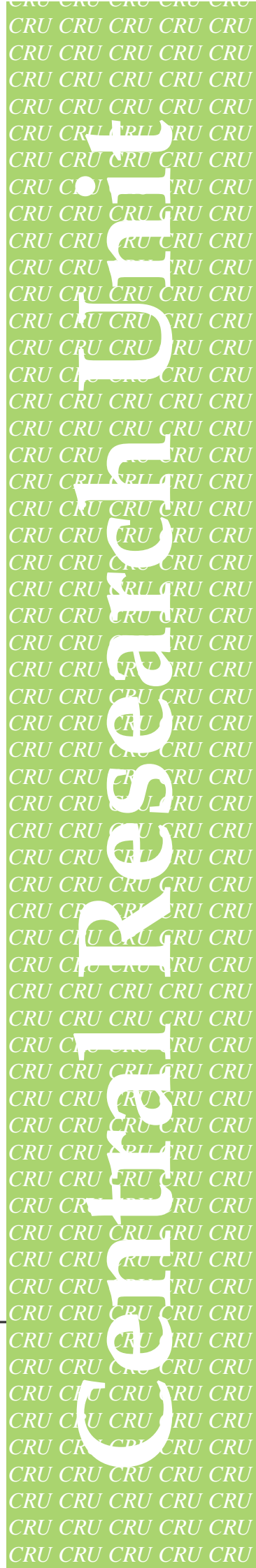


change a lot

POTENTIAL ADAPTATION STRATEGIES FOR CLIMATE CHANGE IN SCOTLAND



SCOTTISH EXECUTIVE



POTENTIAL ADAPTATION STRATEGIES FOR
CLIMATE CHANGE IN SCOTLAND

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2001

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Guy Winter	Scottish Executive: Air, Climate and Engineering Unit
Noranne Ellis	Scottish Natural Heritage
Gill Clark	Scottish Executive: Central Research Unit

LIST OF ABBREVIATIONS

BAP	Biodiversity Action Plan
BETTA	British Electricity Trading and Transmission Arrangements
CAP	Common Agricultural Policy
CHP	Combined Heat and Power
COP	Conference of the Parties to the UNFCCC
DETR	Department of the Environment, Transport and the Regions
DEFRA	Department of Environment, Food and Rural Affairs
DoE	Department of Environment
EU	European Union
GDP	Gross Domestic Product
GCM	General Circulation Model
GHG	Greenhouse Gas
HECA	Home Energy Conservation Act
HMSO	Her Majesty's Stationery Office
ICF	Institute of Chartered Foresters
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention Control
MtC	Million Tonnes Carbon Equivalent
MW	Megawatts
NHER	National Home Energy Rating
OFGEM	Office of Gas and Electricity Markets
ORR	Office of the Rail Regulator
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SRA	Strategic Rail Authority
STB	Scottish Tourist Board (now VisitScotland)
UKCIP	UK Climate Impacts Programme
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

INTRODUCTION

1. This report was commissioned to examine potential Scottish opportunities to moderate the adverse impacts of the changing climate and to realise concomitant opportunities.

2. The study comprised semi-structured interviews with relevant staff from the Scottish Executive combined with a desk-based review of available information from relevant Executive Departments and Agencies and selected external organisations. It draws heavily on the work undertaken as part of the *Climate Change: Scottish Implications Scoping Study* (Kerr *et al.*, 1999) and work of the UK Climate Impacts Programme (McKenzie Hedger *et al.*, 2000).

ADAPTING TO CLIMATE CHANGE

3. Most natural systems and many human activities are sensitive to the changing climate. The extent to which these systems will be harmed by climate change depends both on the magnitude of the change and on the capacity of the natural or human system to adapt. Society's capacity to adapt is dependent on the prevailing socio-economic situation through time. Consequently, understanding the evolving socio-economic situation is as important as knowledge of the likely future climate for identifying vulnerable elements of society. The UK Climate Impacts Programme reflects this in its ongoing work on socio-economic scenarios.

4. Work by the Intergovernmental Panel on Climate Change (IPCC) identifies themes common to climate change adaptation:

- Vulnerability to change is determined by the frequency and magnitude of extreme events and not on average events or changes in average events;
- Adapting to current climate risks are generally consistent with adapting to future changed conditions, so we can usefully deploy them now;
- The capacity to adapt varies by region and through time;
- The enhancement of the capacity to adapt is necessary to reduce vulnerability.

These themes suggest that the existing policies and infrastructure for dealing with current extreme weather events are a good guide to our capacity to cope with future climate change. The themes also emphasise the importance of policies that enhance the capacity to manage change, by building in flexibility, rather than allow the stagnation of embedded practices.

POTENTIAL ADAPTATION STRATEGIES

5. The Intergovernmental Panel on Climate Change also details generic objectives for adapting to climate change:

- Improving the robust design of infrastructure and long-term investments;

- Increasing the flexibility of vulnerable managed systems (e.g. changing activity or location and reducing expected economic lifetimes);
- Enhancing the adaptability of vulnerable natural systems (e.g. reducing non-climatic stresses);
- Reversing decisions that work against effective adaptation (e.g. slowing development in vulnerable areas like flood plains);
- Improving the preparedness and awareness of society.

The extent to which such options can be undertaken in Scotland will reflect the constraints and opportunities built into the existing legislative framework, in addition to the uncertainty surrounding future socio-economic and climatic change. In this sense, climate adaptation strategies are simply a form of risk management.

6. Taking decisions in the face of uncertainty requires an assessment of the relative risk of the available options. These choices can involve significant costs and other social and environmental impacts. Economic frameworks for appraising options exist but there are inherent difficulties when measuring non-economic social and environmental benefits. The chosen option will depend on the prevailing understanding of the situation and the decision-maker's objectives and will usually involve a trade-off between social, economic and environmental ideals.

7. Many public and private institutions within Scotland have responsibilities with respect to climate impacts. This study provides evidence of the considerable extent to which the existing management frameworks either implicitly or explicitly account for climate impacts. Perhaps this should not be surprising given the notoriously changeable and often stormy Scottish weather. Nevertheless, it suggests that an adaptation strategy to climate change in Scotland does not require a fundamentally different framework to that already existing. Climate measures must be integrated into an existing, often complex, policy framework with multiple drivers and demands on resources.

8. Two important implications from the results of this project are:

- There is a natural (and healthy) tension when managing climate impacts between the requirement for strategic planning and the requirement for local decisions to implement appropriate adaptation strategies;
- Many of the difficulties with respect to managing climate change reflect the crosscutting nature of its impacts, which require co-ordination between many different stakeholders within different landscape units.

ENERGY

9. Key Issue:

- The energy supply sector comprises major capital assets with long lifetimes that are vulnerable to flooding and storm damage;

10. Adaptation Strategies:

- By the nature of their business, the energy supply industry should have a good overview of the business risks attached to changing precipitation and rising sea levels;
- Existing Health and Safety Executive (or its Nuclear Installation Inspectorate) frameworks for ensuring the safe operation of power stations appear to be the appropriate vehicle for regular reviews of the structural integrity of power stations to adverse climate impacts;
- The implementation of the EU Water Framework Directive provides a system for catchment abstraction and impoundment control and offers a natural scheme for regulating the environmental impact of excess run-off from the siting and use of hydroelectric plant, which is currently the preserve of SEPA;
- The existing policy framework, which is encouraging substantially more embedded generation, coupled to an assessment of network vulnerability suggests that the wood pole distribution network is most vulnerable to climate impacts. Any refurbishment of such infrastructure requires co-ordination between network operators and the energy regulator.

BUSINESS

11. Key Issue:

- Although specific climate changes may impact directly on individual business operations, particularly at industrial and manufacturing plants, for the majority climate issues will only impinge through the constraints placed on them by planning regulations for land use and building design and from the premiums paid to insure against adverse climate events;

12. Adaptation Strategies:

- The onus is on businesses to take steps to protect their buildings and operations from adverse climate impacts;
- It is in the public interest for public authorities to continue to provide timely information on likely climate impacts and enable appropriate planning by business and to ensure the planning system and building regulations provide a suitable framework for the effective operation of business;
- The present system of management in the transport, energy and water utilities, which have major capital assets with long lifetimes, puts a great onus on the quality of regulatory decisions. Some organisations in some of these industries have argued that the current regulatory system breeds inertia that impedes flexible adaptation to climate change. Encouraging the integration of the management of climate risk into business plans must begin with the industry regulators.

TRANSPORT

13. Key Issue:

- Maintenance of road and rail network, particularly against flooding and storm damage. The rail network is inherently more vulnerable than the road network.

14. Adaptation Strategies:

- The fragmented nature of the railways industry does not lend itself to strategic thinking. An adaptation strategy requires that Railtrack builds climate risk into its management plan for investment priorities. Much depends on the capacity of the Scottish Executive to influence the Strategic Rail Authority and protect the interests of Scottish railways, particularly those that are economically marginal;
- The development of route management plans will enable the prioritisation of road network maintenance. Alternative approaches for reducing flood risk include land use zoning adjacent to roads and the development of Sustainable Urban Drainage Systems by SEPA.

DOMESTIC

15. Key Issue:

- The majority of people own properties not built under recent building regulations and must continue to invest in maintaining the condition of the property, in view of possible increased exposure to driving rain, storminess and coastal/riverine flooding;

16. Adaptation Strategies:

- The onus is on private property owners to take steps to protect their buildings from adverse climate impacts. The use of insurance policies is the most pervasive adaptation technique, but tends to transfer responsibility of property protection away from the owner and on to the insurance company. It is in the public interest to educate property owners about possible climate impacts and opportunities for protecting their property;
- The development of specific insurance policies that reflect foreseeable risks of the locality could be an important factor in reducing the transfer in responsibility from property owner to insurance company.

PUBLIC SECTOR

17. Key Issues:

- The key issue for the public sector concerns the land use planning system and its role in minimising flood risk while allowing appropriate economic development. The National Planning Policy Guidelines on Flooding and Planning (NPPG7)

provide a comprehensive framework to minimise the risk of flooding from future developments.

- Poor health arising from damp, cold housing is likely to worsen.

18. Adaptation Strategies:

- To move from the current approach to the development of flood defences, which is primarily reactive, to a more proactive approach requires better data on flood risk in key catchments and coastal areas across Scotland;
- Minimising flood risk in future requires a more strategic view of flood prevention across the landscape. Planned flood defences are simply keeping abreast of current flood hotspots that have arisen from previous planning decisions. A more sustainable approach to reduce flood risk, such as upstream ponding, requires co-ordination between catchment landowners and makes more demands on stakeholder involvement;
- Detrimental health impacts from the changing climate could be reduced through the effective implementation of current social policies to reduce fuel poverty and improve housing;
- The public sector plays a key role through education in raising awareness and facilitating an understanding of the opportunities and risks associated with climate change.

AGRICULTURE, FORESTRY, FISHING AND BIODIVERSITY

19. Key Issue:

- The management of Scotland's natural resources is the sector most sensitive to climate change. The results from this project suggest that, above all else, adapting to climate change demands flexibility in resource management. Defining and attempting to conserve practices or one species in a fixed location are likely to fail.

20. Adaptation Strategies:

- The offshore fishing industry is perhaps most vulnerable, not least because of the failings of the current fisheries management regime. Adapting to climate change requires an ecosystem approach to sustainable fisheries management and must be integrated into the ongoing revision of the Common Fisheries Policy;
- The results from this study suggest that even to pose appropriate questions about the impacts of climate change on land use requires a more co-ordinated vision than is currently the case. The fragmented and often overlapping nature of policies for forestry, agriculture and biodiversity impedes appropriate adaptation strategies. In the medium-term, drivers of change from agriculture, from mitigating greenhouse gas emissions, from sustainability issues and from the protection of biodiversity may lead to a blurring and perhaps complete removal of the distinctions between policies for forestry, agriculture and biodiversity;
- The use of strategic landscape units is common when managing natural resources and could be employed usefully in Scotland to explore appropriate climate strategies.

PRIORITIES FOR FUTURE WORK

21. The results from this study suggest that the priorities for a climate change adaptation strategy in Scotland should reflect the following:

- Climate risk management is integrated into the planning process of all organisations with responsibilities for long life assets. For example, for the water authorities, as a major holder of long-life assets, the adaptation priority is to develop infrastructure robust to present weather extremes, by integrating climate risk into business planning and investment;
- Mechanisms are in place to continually monitor and disseminate climate scenario information, as it becomes available;
- The delicate balance between minimising climate risk and enabling social and economic development through the land use planning framework is observed;
- Existing management frameworks in Scotland are utilised, but the development of local stakeholder groups are also critical for developing a strategy based on the joint strengths of strategic oversight by the Scottish Executive and local decision-making;
- The use of strategic management frameworks for defined landscape areas within Scotland would assist the development of adaptation policies;
- The development of measures to minimise greenhouse gas emissions from land use must be designed in conjunction with measures to minimise adverse climate impacts;
- Information on the land at risk of flooding is fundamental for an adaptation strategy in Scotland;
- The Scottish Executive plays a vitally important role as an educator, to improve awareness and disseminate information on climate risk, and as a facilitator, to encourage groups of stakeholders to integrate climate risk into their management strategies

CHAPTER ONE INTRODUCTION

AIMS OF THE STUDY

1.1 This study aims to identify potential Scottish opportunities to moderate the adverse impacts of the changing climate and to realise concomitant opportunities.

1.2 The study comprised semi-structured interviews with relevant staff from the Scottish Executive combined with a desk-based review of available information from relevant Executive Departments and Agencies and selected external organisations. It draws heavily on the work undertaken as part of the *Climate Change: Scottish Implications Scoping Study* (Kerr *et al.*, 1999) and the work of the UK Climate Impacts Programme (McKenzie Hedger *et al.*, 2000).

THE REPORT IN CONTEXT

1.3 The UK and Scottish Climate Change Programmes, which were published in November 2000, consider in detail the policies and measures required for reducing the emissions of polluting gases responsible for human-induced climate change (DETR, 2000; Scottish Executive, 2000a). The European Union has suggested that a 'sustainable' target for climate change is an increase in average global temperature of only 2°C above the pre-industrial level by 2100 (EEA, 1999), which is consistent with the United Nations-suggested limit for acceptable change of 0.1°C per decade. These figures provide the basis for international negotiations on reducing emissions of greenhouse gases. However, even if the UK and all other developed countries meet their emissions targets set for 2008-2012 under the Kyoto Protocol the global climate will continue to change as a result of the existing level and ongoing emissions of greenhouse gases into the atmosphere.

1.4 The Scottish Climate Change Programme therefore makes clear that in addition to measures for reducing these greenhouse gas emissions there is a need to examine whether Scotland is adequately prepared for the adverse impacts of future climate.

1.5 The *Climate Change: Scottish Implications Scoping Study* consulted a total of 74 stakeholders, representing six key sectors affected by climate change: energy; transport, domestic; public sector; business; and agriculture, forestry, fisheries and biodiversity. The respondents provided information on the sensitivity and the vulnerability of their sector to climate impacts and identified possible adaptation options (Kerr *et al.*, 1999).

1.6 This report builds on the Scottish Implications study and provides an initial assessment of whether the existing policy framework in Scotland is effective for dealing with the changing climate.

1.7 Unlike the recent UK study of potential adaptation strategies (ERM, 2000), this study does not attempt to estimate the costs of possible response options to climate change. In the absence of a common methodology for costing climate impacts, currently being developed for the UK Climate Impacts Programme, and in the absence of agreed 'business as usual' baselines for climate-related expenditure within each sector, it is not clear that a top-down approach to costing the impacts is justifiable.

1.8 Climate change will impact on many countries around the world, often with unforeseen effects. In the longer term and juxtaposed with socio-economic and political changes it is likely to lead to profound realignment in world markets and large-scale migration. Such potential long-term changes are outwith the preserve of this study, which focuses on the short to medium term policy framework within Scotland.

1.9 In addition, this study does not consider the detailed technical or engineering options available to minimise adverse climate impacts, elements of which are covered in the recent Scottish Executive publication, *Climate Change: Review of levels of protection offered by flood prevention schemes* (Price & McInally, 2001).

REPORT STRUCTURE

1.10 Chapter One provides a statement of the aims of the report and reviews the developments in adapting to climate change internationally and in the UK and Scotland.

1.11 Chapter Two describes our understanding of how social, economic and environmental systems might adapt to reduce their vulnerability to a changing or expected change in regional climate. It draws on the extensive work undertaken under the auspices of Working Group II of the Intergovernmental Panel on Climate Change (IPCC) in recent years.

1.12 Chapter Three reviews the evidence for the possible futures – socio-economic and climatic - in Scotland, drawing on the work of the UK Climate Impacts Programme and recent studies funded and undertaken in Scotland on various aspects of climate change. Socio-economic changes are as important as climate change itself in determining appropriate adaptation options.

1.13 The primary information obtained during this study is detailed in Chapter Four. The chapter retains the key socio-economic sectors used in the Scottish Climate Change Programme. The sectors are energy; transport; business; domestic; public sector; and agriculture, forestry, fisheries and biodiversity. For each sector the vulnerability and adaptability of the sector to climate change, as identified in the *Climate Change: Scottish Implications Scoping Study*, is explored in the context of current and forthcoming policies. This report draws heavily on the policy framework set out in the UK and Scottish Climate Change Programmes. This will enable an assessment of gaps in the policy framework and elucidate the capacity of each sector to adapt to climate change.

1.14 Chapter Five synthesises the information provided in Chapter Four in the context of cross-cutting issues between sectors and concludes the report with a series of recommendations for developing a strategy for adapting to climate change in Scotland.

THE CONSEQUENCES OF FAILING TO ADAPT!

During the fourteenth century, the onset of less favourable climatic conditions led to widespread crop failure, hunger and, in some cases, starvation along the northern Atlantic margins of Europe. At this time, many Scottish hill farms were abandoned forever. Plague and war exacerbated this hardship in Europe, but only in Greenland did the crisis lead to total extinction of a society, that of the Norse Greenlanders or Vikings.

The cause commonly ascribed to the extinction of the Norse Greenlanders is that of climate change. Increasingly detailed understanding of the regional climate during that era along with historical and archaeological evidence of the Norse society provides us with clues as to their eventual demise. The most striking aspect of the story is that although the Norse succumbed to the changing environment, the Thule people - ancestors to the Inuit Greenlanders of today, who had migrated across from Alaska - met and interacted with the Norse Greenlanders during the period of their demise and yet managed to prosper.

While the interest by the Inuit in the Norse is apparent from the many Norse objects found in Inuit sites, the converse is conspicuous by its absence. The technology of the Inuit, from the clothing to the hunting harpoons, was to enable them to adapt to the unfavourable weather conditions and survive. However, the Norse appeared to make little or no attempt to adopt the Inuit practices

The evidence speaks of a chilling and chilly end for the Norse. Excavation of the interior floors of farms show a progression from typical homestead farm, to the remains of domestic stock, then to Arctic hare and ptarmigan – regarded by the Inuit as famine food – and finally the partially eaten remains of the farmers own highly-valued hunting dogs.

It is apparent that the situation was not just “it got colder, so they died”, since the Inuit prospered. Modern research has explored the myriad feedbacks between the cultural traditions of a society and their region’s climate and environmental conditions. With hindsight, it would appear that it was a series of conscious decisions by the Eurocentric Norse society that led them down their fateful road, particularly the social and cultural barriers to accepting an Inuit approach. When faced with multiple challenges to the social framework, the Norse Greenlanders chose to elevate cultural tradition over innovation and, ultimately, die rather than abandon their core values.

Source: McGovern (1991; 2000)

Box 2.1 Analysis of past social changes has revealed the potential consequences of failing to adapt to a changing climate.

DEVELOPMENTS IN ADAPTING TO CLIMATE CHANGE

The International Effort

1.15 When planning an effective response to the threat of climate change, society must consider the likely impacts of climate change on their evolving social, economic and environmental systems and explore possible means of adapting to future changes. The Intergovernmental Panel on Climate Change (IPCC), which provided a synthesis of global climate change impacts and adaptation responses in its periodic Assessment Reports in 1990 and 1995 (IPCC, 1995), has led the international effort. While much international research has focused on climate impacts, relatively little work to date has been conducted on the practical application of strategies for adapting to climate change. The Third IPCC Assessment was published this year and provides a more general synthesis of our current understanding of adaptation to climate change (IPCC, 2001). While the IPCC provides a global overview of climate impacts, it is apparent that regional and national climate strategies require a focus on local socio-economic and environmental factors.

1.16 The most comprehensive regional examination of the impacts of future climate and possible adaptation responses has been undertaken in Europe with funding by the European Commission. The *ACACIA Project* assesses the potential effects and potential adaptation to climate change in Europe (Parry, 2000). This resource forms the basis of the European contribution to the IPCC Third Assessment and addresses the following issues in different European socio-economic and environmental sectors:

- The key sensitivities to weather now;
- The main impacts of climate change in the future;
- The most vulnerable regions;
- The array of adaptive options;
- The key implications for other related sectors and other environmental trends;
- The uncertainties and unknowns;
- Policy implications;
- Research implications.

UK Developments

1.17 Work on climate impacts and adaptation in the UK is co-ordinated by the UK Climate Impacts Programme (UKCIP), which was established in 1997 by the then Department of the Environment, Transport and the Regions (now Department for Environment, Food and Rural Affairs - DEFRA). This Programme provides an umbrella organisation to oversee and facilitate integration of the numerous recent and on-going sectoral and regional studies of climate change impacts in the UK. It operates through stakeholder engagement to ensure that the climate impacts research is focused on the needs of users and provides a framework within which different sectors can use common tools and learn from the experience of others. The recently published *Climate Change: Assessing the impacts – identifying responses* provides an overview of the work of the UKCIP since its inception (McKenzie Hedger *et al.*, 2000).

1.18 Underpinning the work of the UKCIP is the development of a series of core products that provide the necessary tools to assess climate impacts and opportunities for adaptation. The four main products are:

- Future climate scenarios for the UK compiled by the Climate Research Unit at the University of East Anglia;
- Socio-economic scenarios or 'story-lines' developed by the Science Policy Research Unit at Sussex University;
- Guidelines on managing risk and uncertainty in decision-making, developed by the Environment Agency and DEFRA;
- A methodology for costing the impacts of climate change by Metronomica.

1.19 The first two products provide a common framework with which to consider possible futures – both climate and socio-economic – that affect how we as a society might adapt to the changing climate. The latter two products are under development and will be published in 2001. Since uncertainty is inherent in the decision-making associated with climate change, guidance in managing risk and uncertainty is being developed. Similarly, the need to justify investment decisions requires a robust methodology for costing the potential impacts of climate change.

1.20 Other related climate work funded by the DEFRA (or its predecessors DETR and the Department of Environment (DoE)) includes early work to improve understanding of local and regional climate impacts by the UK Climate Change Impacts Review Group (CCIRG). Its 1996 report, entitled *Review of the Potential Effects of Climate Change in the UK*, provides a useful baseline study on which to build future climate impacts studies (DoE, 1996). The DoE also commissioned a report to gain some insight into the sensitivity of the UK economy to climate variability and change, entitled *Economic Impacts of the Hot Summer and Unusually Warm Year of 1995*. This latter report concluded that the UK economy is sensitive to climatic variations (Palutikof *et al.*, 1997). It describes both positive and negative impacts in different sectors and noted changes in the sensitivity of the economy to climate over time.

1.21 The DETR funded work to establish a set of indicators of climate change and its impacts on different social and environmental facets of the UK. The results are published in the report *Indicators of Climate Change in the UK* and updated annually (DETR, 1999). These indicators show that the first effects of climate change are already being observed in the UK.

1.22 Work on adapting to climate impacts remains in its early stages in the UK. A recent DETR-funded project by Environmental Resource Management, *Potential UK adaptation strategies for climate change* (ERM, 2000), explored:

- Priorities for possible adaptation responses to the potential effects of climate change over the next 30 to 50 years;
- Analysis of the adaptation responses and a preliminary costing for their implementation;
- The key issues in taking action on adaptation.

1.23 The approach adopted in the Environmental Resource Management study was to use a small stakeholder group of policymakers, academics, business and non-governmental

organisations to agree priority areas for adapting to climate impacts. These responses were then refined and costed. The main difficulties encountered during the study were agreeing an appropriate costing methodology; agreeing appropriate climate scenarios; and assessing the scale of likely impacts, which determine the level of action required. The lack of data necessary for addressing climate risks was also noted.

1.24 Whilst there is much overlap between the adaptation priorities identified by the stakeholders in the UK study and those identified in the *Climate Change: Scottish Implications Scoping Study*, there is an understandable mismatch on themes of specific importance to Scotland. For example, the marine environment plays a proportionately more important role in the economy of Scotland than in that of the UK as a whole. For that reason, this present study draws primarily on the work of the Scottish study.

IMPACTS	ADAPTATION RESPONSES	PLANNING
WATER RESOURCES <ul style="list-style-type: none"> • Lower river flows and groundwater discharge; • Increased water demand in England and Wales; • Deteriorating water quality. 	<ul style="list-style-type: none"> • Supply-side options to increase water supply; • Improve residential water demand-side management. 	<ul style="list-style-type: none"> • Incorporate climate change impacts into land use planning processes; • Review planning policies and guidance; • Integrate climate change into sectoral and regional strategic planning processes and systems.
FLOODING <ul style="list-style-type: none"> • Coastal/river flooding risk increase; • Foul flooding; • Water quality impact. 	<ul style="list-style-type: none"> • Increased flood protection; • Better information. 	
BUILDINGS AND INFRASTRUCTURE <ul style="list-style-type: none"> • Increased subsidence; • Deterioration of external fabric; • Deterioration of internal spaces; • Disruption to rail, road and power supply services. 	<ul style="list-style-type: none"> • Incorporate ‘climate headroom’ into buildings and infrastructure. 	
NATURE CONSERVATION AND BIODIVERSITY <ul style="list-style-type: none"> • Deterioration or loss in value of natural designated sites; • Irreversible loss of some rare habitats and endangered species. 	<ul style="list-style-type: none"> • Protect the designated sites most at risk. 	

Fig 1.1 Key impact areas and potential adaptation strategies (from ERM, 2000)

Developments in Scotland

1.25 In 1998 the then Scottish Office organised and reported on two workshops addressing the Scottish implications of climate change. The first workshop considered the direct impacts of climate change on Scotland and the necessary information required for decision-makers to plan appropriate responses. The second workshop addressed the actions required to mitigate greenhouse gas emissions in Scotland. One of the outcomes of these workshops was the letting of a contract to scope the implications of climate change for Scotland, the results of which were reported in *Climate Change: Scottish Implications Scoping Study* (Kerr *et al.*, 1999).

1.26 The *Climate Change: Scottish Implications Scoping Study* examined the implications of climate change for six socio-economic sectors. The issues covered included identifying the main drivers of change in each sector; the sensitivity of sectors to climate; the vulnerability and opportunities of sectors to the UKCIP 1998 climate scenarios; and possible sectoral adaptation strategies. The results of the scoping study provide the primary source of information on climate impacts used in this report.

1.27 Other recent work funded by the Scottish Executive has explored in more depth the Scottish implications of the UKCIP 1998 climate scenarios. Reports from these studies have been released during the course of 2001. They include:

- Review of flooding occurrences in Scotland and future implications (Werrity *et al.*, in press);
- Climate Change: Review of levels of protection offered by flood protection schemes (Price & McNally, 2001);
- Climate Change: North Atlantic Comparisons (Kerr & Allen, 2001);
- Climate Change and Changing Snowfall Patterns in Scotland (Harrison *et al.*, 2001);
- An exploration of regional climate scenarios for Scotland (Hulme *et al.*, 2001)

CHAPTER TWO ADAPTING TO CLIMATE CHANGE

2.1 This chapter summarises the generic themes associated with strategies for adapting to climate change. This synthesis reflects work undertaken under the auspices of Working Group II of the Intergovernmental Panel on Climate Change (IPCC) and work by the UK Environment Agency (Willows *et al.*, 2000). The IPCC Third Assessment, published this year, covers these issues in more detail (IPCC, 2001).

ASSESSING THE IMPACT OF CLIMATE CHANGE

Sensitivity is the degree to which a system will respond to a change in conditions.

Adaptability defines the extent to which adjustments are possible in a system, in response to an actual or projected change.

Vulnerability defines the extent to which a change in conditions may harm a system. It is a function of both the system's sensitivity and its ability to adapt.

Adapted from IPCC (1995)

2.2 Most natural systems and many human activities are sensitive to the changing climate. The extent to which these systems will be harmed by change depends on the magnitude of change and on the capacity of the natural or human system to adapt. It follows that an assessment of the vulnerability of our society to climate change requires an understanding of both the likely future climate change **and** the evolving socio-economic situation that determines our capacity to adapt.

2.3 In the absence of planning, our society, like natural systems, will adapt autonomously to changing weather patterns, as it will to other changes in social, economic and environmental conditions but the cost and residual damage will probably be higher than if appropriate planning decisions are made. Such autonomous adaptation is reactive and frequently incremental. A review of the way society has responded to climate change in the past suggests that society has tended to muddle through rather than use forward planning (Glantz, 1988). Whilst not necessarily inappropriate as a response, the costs have probably been higher in the longer term. In each case, the society required a catalyst, such as an environmental catastrophe, that indicated the seriousness of the threat in order to act.

2.4 Planned adaptation relies on a deliberate response to identifiable impacts resulting from the effects of climate change. Research has identified many possible measures that could be undertaken in different sectors, but relatively little work on the practical application of public policy measures for adapting to climate change. In practice, such policy measures must be integrated into an existing, often complex, policy framework with multiple drivers and demands on resources. Work exploring the impact of climate change in Scotland illuminates this point by noting that climate change is not the primary driver of change in any one socio-economic sector, though it is an important driver of change for many sectors (Kerr *et al.*, 1999).

2.5 The process of identifying appropriate adaptation strategies has been considered in some detail (e.g. Carter *et al.*, 1994). Generic objectives for adapting to climate change were identified by Klein and Tol (1997) as:

- Increasing robustness of infrastructural design and long-term investments;
- Increasing the flexibility of vulnerable managed systems (e.g. changing activity or location and reducing expected economic lifetimes);
- Enhancing the adaptability of vulnerable natural systems (e.g. reducing non-climatic stresses);
- Reversing maladaptation (e.g. slowing development in vulnerable areas);
- Improving societal awareness and preparedness.

2.6 The extent to which such options can be undertaken in Scotland will reflect the constraints and opportunities built into the existing legislative framework. It is these policy mechanisms that are the focus of this project. Researchers have also explored the opportunities and barriers for adapting to a changing climate (see for example, IPCC 1995). This includes numerous possible measures and initiatives that have the potential to moderate adverse impacts in various sectors. Perhaps more usefully, this work also identifies common themes when developing a strategy for adapting to change:

- Vulnerability to change is determined by the frequency and magnitude of extreme events and not on average events or changes in average events;
- Adaptations to current climate risks are generally consistent with adapting to future changed conditions, so we can usefully deploy them now;
- The capacity to adapt varies by region and through time;
- The enhancement of the capacity to adapt is necessary to reduce vulnerability.

2.7 These themes suggest that the existing policies and infrastructure for dealing with current extreme weather events are a good guide to our capacity to cope with future climate change. The themes also illuminate the importance of ensuring that the evolving policy framework is predicated on enhancing the capacity to manage forthcoming change rather than allowing stagnation and the emergence of barriers to adaptation. The focus of the research in this project is on the existing and planned organisational structures and remits within Scotland and their capacity to cope with climate change in the context of ongoing social, political and economic change.

ADAPTATION STRATEGIES AS RISK MANAGEMENT

2.8 Many public and private institutions within Scotland have responsibilities with respect to climate change under the existing legislation – they represent the adaptive management to climate change. Such agents face multiple policy criteria, often with conflicting objectives, along with the need to take decisions in the face of uncertainty.

2.9 Similarly, the development of a strategy for adapting to climate change must operate within the limits of scientific certainty about future climate and socio-economic change. In this sense, climate adaptation strategies are simply a form of risk management and are best implemented if they are a component of or a modification to an existing management programme.

2.10 Another application of climate adaptation strategies is to take a long-term overview of a sector, firm or organisation's activity. The development of measures to adapt to climate change can help in re-thinking organisational goals and values, and in re-organising and re-engineering the provision of goods and services to customers and users. One example of this is the way climate change has forced the question of what is the 'end point' of a biodiversity policy, given that a static view of nature conservation is not viable.

2.11 The need to take decisions in the face of uncertainty has led to the development of decision frameworks to enable policy-makers, managers and stakeholders to implement appropriate techniques for managing risk. One example of such a decision support tool is the series published by MAFF on the appraisal of flood and coastal defences in England and Wales (MAFF, 2000). A more generic decision support tool for uncertainty associated with climate change is being developed by the Environment Agency (see figure 2.1), entitled *Climate Adaptation Risk and Uncertainty: Draft Decision Framework* (Willows *et al.*, 2000). This tool conforms to the DETR (now DEFRA)/Environment Agency framework on environmental risk assessment and management, while reflecting the particular characteristics associated with adapting to climate change.

2.12 The framework draws attention to the types of uncertainty that permeate decisions associated with climate change:

- 'Real world' uncertainty, such as the evolution of complex, unpredictable human and natural systems;
- Data uncertainty, arising from measurement error and incomplete data;
- Model uncertainty, including whether the form of model, the choice of output variable or the validity of model parameters under changed conditions are appropriate to answer the questions posed of the model;
- Knowledge uncertainty, arising from our incomplete understanding of the interaction between natural and human processes.

2.13 Taking decisions in the face of uncertainty requires an assessment of the relative risk of the various options available. This risk assessment combines knowledge of both the probability of events and their consequences. The option chosen will depend on the objectives of the decision-maker, which will usually involve a trade-off between social, economic and environmental ideals. Strategies for adapting to climate change will involve one or more of the following options:

- Assess risk and appraise options;
- Delay action;
- Buy time;
- Gather information and data;
- Monitor:
 - Performance;
 - Climate impacts;
- Educate and provide information;
- Plan contingency;
- Diversify and bet-hedge;
- Insure;
- Defend and manage;
- Retreat and change use;

- Retreat and abandon;
- Enhance safety factors, design headroom and buffering measures.

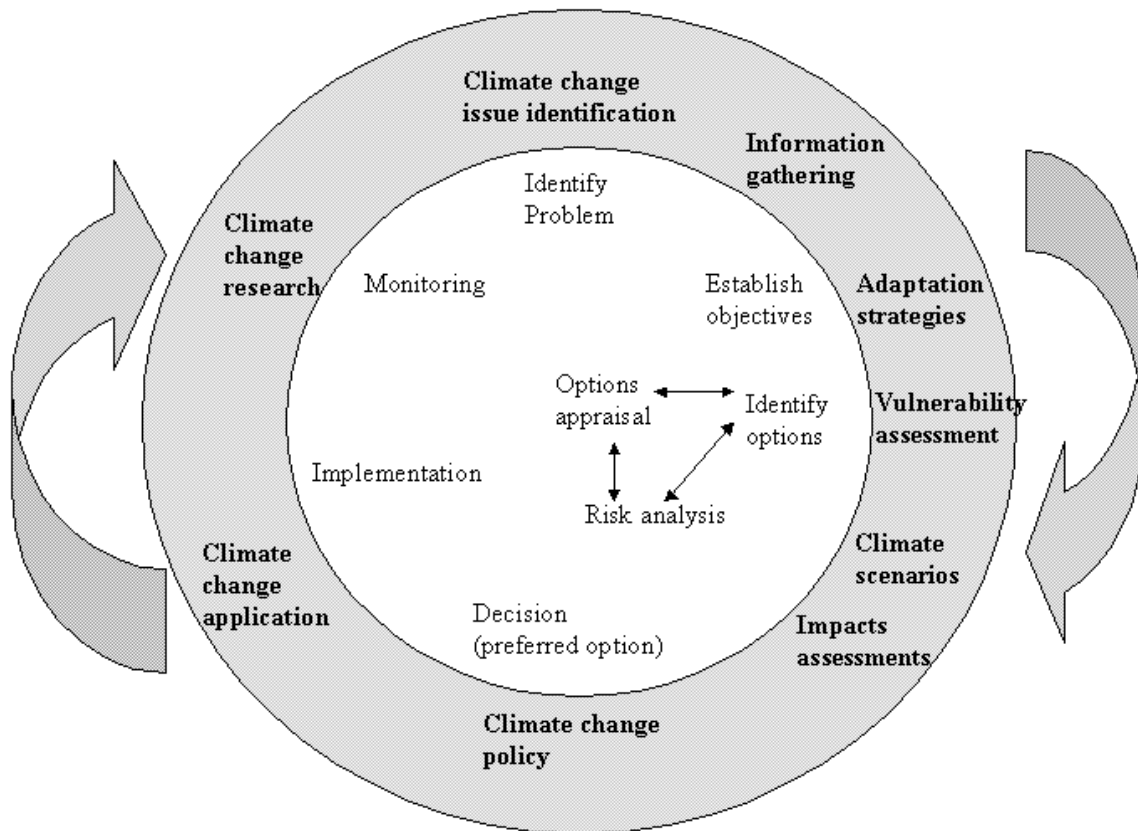


Fig. 2.1 A generic framework for climate change decision making that includes the analysis of risks and uncertainty (from Willows *et al.*, 2000).

2.14 Many of the options considered in an assessment will involve choices regarding the extent to which the adaptation should be carried out, the choice of an endpoint for the change and the timing of implementation. These choices can involve significant costs and other environmental and social impacts. Economic frameworks for appraising the appropriate option exist in the form of cost-benefit analysis and multi-criteria analysis, though there are inherent difficulties with both when measuring non-economic social or environmental benefits for projects.

2.15 The aim of any appraisal of adaptation options is to seek the ‘best’ option given the prevailing understanding of the situation and the objectives of the decision-maker. Both of these will change through time, so one element of any strategy is to enhance the flexibility or robustness of the decision-making process to cope with change.

CHAPTER THREE POSSIBLE FUTURES FOR SCOTLAND

3.1 Chapter Three provides a review of published work, predominantly by the UK Climate Impacts Programme, providing scenarios of future climate in Scotland and trends in its socio-economic development. The extent to which Scotland is vulnerable to future climate impacts depends on both the magnitude of the climate change and on the capacity of the Scotland's society to adapt. It follows that we require an understanding of both the likely future climate change **and** the evolving socio-economic situation that determines our capacity to adapt.

SOCIO-ECONOMIC SCENARIOS

3.2 “The consequences of changing climatic conditions will be determined to a considerable extent by the nature of the economic, social and technological domain in which those impacts occur. It is thus essential to develop a view of the world in which future climate will be felt.” (McKenzie Hedger *et al.*, 2000). Socio-economic scenarios for the UK that reflect the range of possible developments in society in the UK have been developed under the auspices of the UK Climate Impacts Programme (Berkhout *et al.*, 1999). Their work builds on the work of the IPCC Third Assessment Report and work by the Office of Science and Technology Natural Resources and Environment Foresight Panel.

3.3 The scenarios in figure 3.1 provide a conceptual framework of the drivers of change on society.

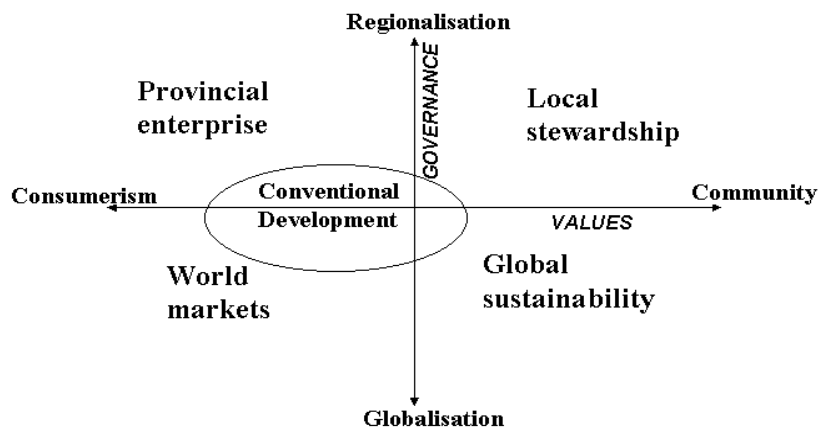


Fig. 3.1 The conceptual framework of the four national non-climate scenarios (from Berkhout *et al.*, 1999).

3.4 For example, the extent to which the principles of sustainable development are implemented within the policy framework will affect the choice of adaptation options open to the decision-maker. In the case of these socio-economic scenarios, strict adherence to the principles of sustainable development will be represented by society shifting to the right in the diagram, towards global sustainability and/or local stewardship of resources. Conversely,

a society with a vibrant economy may be resilient to climate change because resources will be available to respond to the impacts. The socio-economic framework to date has focused on the UK level. Further development of these scenarios by UKCIP will focus on their regional characterisation.

3.5 Other explorations of future scenarios in Scotland include work by Scottish Enterprise and VisitScotland (formerly the Scottish Tourist Board). For example, the former provide evidence of the impact of the changing economic environment on Scottish business by highlighting fundamental trends such as:

- Consumers have become richer and more sophisticated;
- Political and economic liberalisation and deregulation are pervasive; and
- Technological development and application is rapid and widespread;

as a result of which is emerging the ‘knowledge economy’ (Whyte, 1998).

Tracking the Bigger Picture: Baselines, Milestones and Benchmarks for the Scottish Economy

The *Tracking the Bigger Picture* project is being developed by Scottish Enterprise with the support of partner organisations to track the performance of the Scottish economy. This will help inform new policy development and monitor the progress of existing strategies. Specifically the project will:

- track socio-economic performance against a core set of indicators;
- assess national progress towards strategic goals;
- compare Scotland's economic performance against other appropriate economies;
- gain a wider understanding (and explanation) of absolute and relative economic trends;
- explore longer term impact of intervention;
- identify broad strategic messages/issues for Scotland.

The '**Baselines**' element of the project monitors a wide range of existing indicators covering three major 'themes':

- economy
- people and
- quality of life/environment.

The '**Milestones**' element tracks indicators that are specifically aligned to Scottish Enterprise strategic goals. Examples include:

- e-commerce take up
- number of new businesses
- % households below 50% average income.

The '**Benchmarks**' element compares Scotland's progress against that of a broadly comparable range of economies (i.e. those which have similar size, economic policy/history, drivers of change, etc). Examples include Ireland, Finland, and Massachusetts. As well as measuring general indicators (e.g. GDP, employment) the drivers of change in each economy will be analysed to provide a qualitative as well as quantitative understanding.

Outputs

There will be two principal outputs from the project which are available as a web based resource:

- The databases, which will be updated regularly and available to the public;
- An annual report providing an overview of each data base.

Box 3.1 The Scottish Enterprise project that provides a synopsis of the development of the Scottish economy.

CLIMATE SCENARIOS

3.6 To date the most authoritative published information on projected climate change in the UK is derived from the UKCIP98 scenarios developed for the UK Climate Impacts Programme (Hulme and Jenkins, 1998). This work is being updated with new scenarios to be published in 2002. In the UKCIP98 work, four scenarios are presented to represent a 'reasonable' range of possible future climates for the UK, reflecting different assumptions about the following sources of uncertainty:

- The levels of greenhouse gas emissions from society in future;
- The sensitivity of the climate system to the changing atmospheric concentration of greenhouse gases;
- Internal differences between global climate models.

3.7 Specific probabilities cannot be attached to the four scenarios, so an evaluation of likely climate impacts requires that all four scenarios be considered. The four scenarios are labelled **Low**, **Medium-low**, **Medium-high** and **High** which reflect their respective rates of global warming. The **Medium-high** and **Medium-low** scenarios encompass a range of future greenhouse gas emissions from society. The **Medium-high** scenario is based on an annual increase in carbon dioxide concentration of 1 %, while the **Medium-low** scenario is forced with a per annum increase in carbon dioxide concentration of 0.5 %. These are similar to the greenhouse gas emissions scenarios set out in the IPCC IS92a and IS92d socio-economic scenarios and exhibit future climates in the mid-range of possible global climate change. The **High** and **Low** scenarios aim to span the different climate sensitivities exhibited by different climate models. These scenarios are derived from the **Medium-high** and **Medium-low** scenarios respectively, by scaling their outputs to reflect an appropriate range of climate sensitivities. Three future time periods are considered: 2010 to 2039 (termed the 2020s); 2040 to 2069 (termed the 2050s); and 2070 to 2099 (termed the 2080s).

3.8 In order to interpret the scenarios for assessing climate impacts, the uncertainties inherent in their results must be explicitly detailed. The model developers provide a subjective ranking of their level of confidence in the climate results:

Climate attribute	Level of confidence
Atmospheric CO ₂	High confidence
Global mean sea level	↓
Global mean temperature	
Regional seasonal temperature	
Regional temperature extremes	
Regional seasonal precipitation	
Regional cloud cover	
Changes in climatic variability e.g. daily precipitation regimes	Low confidence
Climate surprises (e.g. shifts in ocean currents or ice sheet collapse)	Very low or unknown

3.9 The UKCIP98 scenarios are also limited by their spatial resolution, which only resolves mainland Scotland into two grid boxes approximating to central and northern Scotland and southern Scotland and northern England. This has several implications, not least that the forecast climate change across the heterogeneous environment of Scotland cannot resolve east-west nor altitudinal variations across the country.

3.10 Kerr *et al.* (1999) used the UKCIP98 climate scenarios to investigate climate impacts in Scotland for the *Climate Change: Scottish Implications Scoping Study*. These scenarios (Hulme and Jenkins, 1998) suggest that:

- Over the next century, Scotland will become warmer. Average temperatures are likely to rise by between 1.2 to 2.6°C, with relatively more warming in winter than summer;
- Annual precipitation is likely to increase by between 5 and 20 per cent by the end of the next century, with autumn and winter seeing the biggest increases. In contrast, spring amounts will be lower and there will be little change in summer;
- The intensity of rainfall events is likely to increase, leading to increased risk of flooding;
- There may be an increase in the frequency of very severe gales but a decrease in the number of gales overall;
- The water balance is likely to remain favourable;
- Direct short-wave solar radiation is likely to reduce over the next century as a result of increased cloud cover.

3.11 The natural variability of the climate makes it difficult to attach high levels of significance to some of these suggested changes, particularly those associated with extreme events and or where large natural variability is inherent. Other low probability but high impact events, such as major changes in the ocean circulation of the North Atlantic, are the focus of much basic science within the UK and abroad. It is not possible at present to provide either a probability or a time-scale for such events and beyond recommending that appropriate monitoring and research networks are funded these possibilities are not considered further in this report.

3.12 Harrison *et al.* (2001) and Price and McNally (2001) provide more detailed analysis of the implications of these UKCIP98 scenarios for Scotland. Harrison *et al.* (2001) present a detailed examination of the complex nature of changing snowfall patterns under possible future climates. Price and McNally (2001) present an examination of the level of protection afforded by current flood protection schemes. They conclude that while there is insufficient information to assess in detail the impact of climate change on flood risk it is clear that the level of protection provided by existing flood prevention schemes will be eroded as a consequence of climate change.

3.13 The review of long-term records by Price and McNally (2001) suggests that trends in global temperature and sea level are apparent, but trends in other flood related variables cannot be reliably identified within the natural variability evident from Scottish records. Nevertheless, they note that many changes in flood-related factors have been observed in Scotland during the last few decades of the twentieth century. These include more intense winter precipitation; more winter rainfall (particularly in the west); increased frequency of floods; reduction in snow lie; and increased mean wave height in the North Sea and the Atlantic. Many of these changes have been related to the prevailing Scottish weather conditions, which in turn has been linked to the decadal changes in regional atmospheric pressure known as North Atlantic Oscillation. It remains unclear as to the extent to which changes in the North Atlantic Oscillation can be linked to anthropogenic forcing of the global climate system.

3.14 Work to improve the resolution of the climate scenarios is in hand. Hulme *et al.* (2001) explore the use of regional climate change scenarios in Scotland, the results of which suggest that applying such models can provide meaningful results at higher resolution though it is not necessarily providing us with fundamentally different insights to patterns of regional change. This work will be developed in the forthcoming UKCIP2001 climate scenarios,

which will adopt a grid cell dimension of 50 km. Nevertheless improved precision is not equivalent to improved accuracy and the accuracy of the high resolution scenarios will still depend on the quality of the global circulation model in which the regional scenarios are embedded (McKenzie Hedger *et al.*, 2000).

CHAPTER FOUR EXISTING FRAMEWORK FOR MANAGING CLIMATE IMPACTS

4.1 This chapter assesses the existing framework for managing climate impacts in six Scottish socio-economic sectors. This approach provides a structure within which gaps in information and responsibility become readily apparent. Details from each sector include:

- The current management and policy frameworks;
- The sensitivity and vulnerability of the sector to climate impacts, using information supplied by the *Climate Change: Scottish Implications Scoping Study*;
- The options currently employed to manage climate impacts and the responsibility for assessing resources and monitoring these options.

4.2 This report considers whether the existing management options and policies facilitate an appropriate response to the changing climate. Specifically, whether the current mechanisms reflect that:

- Vulnerability to change is determined by the frequency and magnitude of extreme events and not on average events or changes in average events;
- Adaptations to current climate extremes are generally consistent with adapting to future changed conditions, so we can usefully deploy them now;
- Our capacity to adapt will vary by region and through time;
- The enhancement of the capacity to adapt is necessary to reduce vulnerability.

4.3 The UK and Scottish Climate Change Programmes provide a visualisation of the likely future cross-cutting policy framework in Scottish socio-economic sectors, over the short to medium term. This report uses these as a guide to future socio-economic change in Scotland and focuses on vulnerability to climate impacts that such policies will engender.

ENERGY SUPPLY SECTOR

Existing management and policy framework

4.4 Responsibility for delivering energy lies with the privatised energy generators, which are regulated by the Office of Gas and Electricity Markets (Ofgem). The key players are ScottishPower and Scottish and Southern Energy, who between them own all the non-nuclear power stations, along with British Energy who operate the nuclear stations. There are also about 30 private generators in Scotland, accounting for around 2% of generation. The energy industry has undergone substantial structural change during the last 10 years as a result of the ongoing development of competitive energy markets. At privatisation the two non-nuclear companies remained vertically integrated, retaining control of the separate functions of generation, transmission and supply.

4.5 Proposed structural reforms in the electricity market will culminate in a single British electricity market, dubbed the British Electricity Trading and Transmission Arrangements (BETTA), in 2002.

4.6 Ofgem and its powers were developed under the Gas Act 1986, the Electricity Act 1989 and the Utilities Act 2000. The latter Act provides a new principal objective for the regulator to protect the interests of consumers and a duty to have a regard to guidance issued on social and environmental matters by the UK Secretary of State for Energy.

4.7 Energy policy is a reserved matter for the UK Government under the devolution legislation. Current UK Government policy is to ensure secure, diverse and sustainable supplies of energy at competitive prices. However, some functions have been “executively devolved” to the Scottish Ministers, enabling them to take decisions on energy matters within the framework of the UK energy policy. The most visible of these functions, along with energy efficiency, are:

- The promotion of renewable energy;
- Duties and powers of consent for power stations and overhead power lines.

4.8 As part of the long-term response to reducing emissions of greenhouse gas, the UK Government has proposed that 10% of UK electricity requirements should be met from renewable sources by 2010 (DETR, 2000). This Renewables Obligation will require all licensed electricity suppliers to supply their customers with a specified proportion of electricity from renewable sources¹. The Scottish Executive aims to increase Scottish renewable energy generation to at least 17-18% by 2010. This new Renewables (Scotland) Obligation is likely to be met predominantly by wind power (Scottish Executive, 2000a).

4.9 In preparation for the development of these resources, the Scottish Executive has revised its National Planning Policy Guideline on renewable energy (NPPG6). NPPG6 is now designed to have an enabling role in the development of renewable energy, whilst maintaining planning controls to protect natural heritage.

4.10 The development of such renewable sources and the concomitant encouragement of combined heat and power (CHP) technology by Government will lead to an expansion of embedded generation. The term embedded generation is used to describe energy sources that are connected to the low-voltage distribution networks rather than the high-voltage transmission systems. These low-voltage distribution networks are not currently designed for extensive embedded generation, so Government and the industry are exploring the issues that constrain its future development.

4.11 The transmission network consists of the high-voltage lines (440kV, 275kV and 132kV) that are predominantly near urban areas across the Central Belt and along the East Coast. There are also connections down both East and West Coasts to England. Scotland's transmission network is generally well planned, though there is only a limited network in regions to the north west of a notional line running from Clyde to Perth and Dundee because of the low population density and the location of the present electricity generating stations. Development of renewables generating capacity in this area would require substantial investment to enable further carrying capacity. The distribution network comprises the low-voltage network carrying less than 132kV. It evolved in an ad-hoc fashion with the development of urban areas in recent decades. The result is a non-optimum layout.

¹ The Utilities Act allows suppliers to purchase Green Certificates rather than taking delivery of renewable energy over the grid or to buy out their Obligation for any one year. These alternatives aim to safeguard consumers from high costs if there are delays to the development of renewable energy sources.

4.12 At present, Scotland is a net exporter of electricity to England and Wales. This export is likely to increase in future years through the forthcoming interconnector between Scotland and Northern Ireland and the upgraded interconnector with England. The nuclear power stations and the gas-fired power station at Peterhead meet the base-load demand for Scotland's electricity. It remains unclear what will replace nuclear-generated electricity once Hunterston and Torness close which is scheduled for around 2011 and 2021 respectively.

4.13 The UK Government's Performance and Innovation Unit (PIU) is undertaking a review of the strategic issues surrounding energy policy within the context of meeting the challenge of global warming, while ensuring secure, diverse and reliable energy supplies at a competitive price. The project is due to report by the end of 2001.

Sensitivity of sector to climate impacts

4.14 The *Climate Change: Scottish Implications Scoping Study*, reflecting the views of respondents from the energy generating companies, described elements of climate change to which the industry was sensitive:

- Changing precipitation patterns and intensities, which affects hydropower reservoir infrastructure and use;
- An increase in the intensity of storms, which impacts on transmission and the infrastructure;
- Rising sea levels, because the need for large volumes of cooling water has led to development of power stations on coastal sites.

Options currently employed to manage climate impacts

4.15 Of these elements, respondents to this study noted that by the nature of their business, the industry had a good overview of the business risks attached to changing precipitation patterns and rising sea levels.

4.16 Scottish and Southern Energy are primarily responsible for large hydroelectric plant in Scotland. They are currently in the middle of upgrading their hydro-infrastructure. Respondents to this study indicated that Scottish and Southern had, by necessity, appropriate upland rainfall data and catchment planning.

4.17 As operators of the transmission and distribution network, ScottishPower and Scottish and Southern Energy are responsible for meeting the costs of repairing storm damage. It is in their interest to ensure that an appropriate level of protection exists. In the *Climate Change: Scottish Implications* study, the operators considered that future climate projections are insufficiently precise to plan a refurbishment of the entire infrastructure (Kerr *et al.*, 1999). The received opinion was that the large cost, which will require regulator approval, means further refinement of climate impacts work, as well as further direct experience of weather-induced damage, will be required before companies take action. Structural impacts on power stations resulting from a change in storminess are unclear.

4.18 The power station operators are responsible for their safe operation in the face of sea level rise. For example, British Energy are required to adopt a precautionary principle to climate change issues, underpinned by a 'Periodic Safety Review' of each of their stations over a 10 year cycle. The review examines structural coherence of the station to adverse

climate conditions, including sea level rise, and makes appropriate recommendations for adapting to change.

Who pays?

4.19 Ultimately, the funding for ensuring an energy supply infrastructure that is robust to likely climate impacts will come from electricity customers in the form of bills or through Government subsidies for the development of renewable energy. The regulator will seek to ensure that the interests of the customer are paramount.

4.20 The issues for the electricity supply industry are similar to those facing the rail and the water industries. In each case, a balance must be struck between the needs of upgrading infrastructure to ensure the long-term viability of the network and the costs to the consumer.

Adaptation strategy for the energy sector

4.21 With reference to the generic objectives of an adaptation strategy, discussed in paragraph 2.5, the need for increasingly robust design of its long-term infrastructure is a key issue for the energy sector. The climate impacts are determined by the location of energy supply infrastructure. This includes the transmission and distribution networks; the siting of coastal power stations or offshore rigs; and the siting and use of hydroelectric plant. In each case, the market is the determinant of the location of the infrastructure, within the usual planning guidelines. Over the next two decades, this market will be driven by the policy requirements for an expansion of renewable sources of energy and the likely replacement of the existing nuclear power stations.

4.22 Of the existing transmission and distribution network, the low-voltage wood pole network, carrying 11kV, appears to be most vulnerable to current extremes of weather. Storm damage to this component of the network has, on a number of occasions in recent years, severely disrupted electricity supplies in different parts of the country. While the UKCIP98 scenarios are ambivalent about an increase in storms or their intensity, a theme of good adaptation strategies is to adapt to current climate extremes since this is consistent with adapting to future changed conditions. The vulnerability of the wood pole network reflects:

- Poles are often in exposed positions;
- The infrastructure is ageing, some 30-40 years old;
- It is not clear that appropriate maintenance has been undertaken over the course of the network lifetime;
- It is not clear what design standards were used;
- The distribution network is where the embedded generation will be injected into the network.

4.23 Management frameworks exist within the industry for ensuring the safe operation of existing power stations and they are regulated by the Health and Safety Executive (or its Nuclear Installation Inspectorate). Such mechanisms appear to be the appropriate vehicle for regular reviews of adverse climate impacts, as already happens through the Periodic Safety Reviews required of British Energy for their power stations.

4.24 Excess water run-off from the siting and use of hydroelectric plant comes under the remit of the Scottish Environment Protection Agency (SEPA). SEPA has a duty to promote

the cleanliness of controlled waters and to conserve, so far as practicable, water resources. Consultation with SEPA is undertaken for all new hydroelectric plant, both for small-scale projects covered by planning legislation and larger schemes authorised under the Electricity Act 1989 (NPPG6). This mechanism remains a means of monitoring and adapting to any changes in precipitation patterns. The implementation of the EU Water Framework Directive, which requires a system of abstraction and impoundment control within catchments, provides a more overarching system for monitoring and adapting to future climate change. At the time of writing, work is in hand in preparation for the implementation of the Directive.

Adaptation Priorities

4.25 The existing policy framework, which is encouraging substantially more embedded and renewable generation, coupled to an assessment of the climate risk to the energy supply sector suggests that the priorities are:

- Developing an increasingly robust wood pole distribution network;
- Implementing the Water Framework Directive to enable an appropriate system of abstraction and impoundment control within catchments.

The former priority is a matter for discussion between the public electricity suppliers and the energy regulator, while the latter reflects the needs for effective planning of further hydroelectric schemes.

BUSINESS

4.26 This section considers the management of climate impacts in the private sector. The tourist and insurance industries are analysed in more detail. The insurance business plays a critical role in providing one of the primary adaptation strategies open to business and consumers. It is also vulnerable itself if it fails to assess the climate risk properly and offers inappropriate premiums.

Existing Management and Policy Framework

4.27 The Advisory Committee on Business and the Environment report, *Climate Issues for Business*, highlighted the need for individual businesses to explore the available climate scenario information and take appropriate steps to manage their response (ACBE, 1998). Climate impacts that impinge on specific business operations, such as higher temperatures or increased rainfall and wind, are obviously matters for the businesses themselves. Compared to other sectors, the business sector prides itself on having the management structures to respond to the opportunities and threats from impacts of climate change flexibly and incrementally.

4.28 Although specific climate changes may impact directly on individual business operations, for the majority climate impacts will impinge only through the constraints placed on them by planning regulations for land use and building design and from the premiums paid to insure against adverse climate events.

4.29 Consultation with business by the UK Climate Impacts Programme suggests that the capacity of the business sector to adapt to climate change will be influenced by two key factors (McKenzie Hedger *et al.*, 2000):

- Time-scale of operation;
- Resource base of the affected business.

4.30 The use of climate scenarios that forecast changes in climate 20 to 100 years hence does not capture the attention of most businesses, particularly small and medium enterprises, for which a five-year plan is rare. McKenzie Hedger *et al.* (2000) argue the need to raise awareness of the opportunities and threats posed by climate change and to orientate such information on time-scales appropriate to business decision-making. In general, industries for which climate presents a credible business risk, such as those with long planning horizons or which manage natural resources, are those with a good grasp of the issues. Examples of these industries include the energy supply and water industries. In these cases, the companies and regulator must attain an appropriate balance between the interests of the consumer and the necessary level of investment to maintain the long-term viability of infrastructure (see sections on energy and the public sector).

4.31 Respondents to the *Climate Change: Scottish Implications Scoping Study* suggested that climate change issues rarely influence business decision-making, which is driven by the market within the existing policy framework. Nevertheless, climate will impinge on business decisions through the business use of land and infrastructure. Here, public authorities play a key role in ensuring an appropriate planning framework to allow the effective operation of business.

4.32 The policy mechanisms by which the Government seeks to minimise greenhouse gas emissions from business, particularly the Climate Change Levy, are producing a step shift in business awareness of energy use. One consequence of this, in conjunction with the work of the Scottish Energy Efficiency Office and the Energy Savings Trust, is to create more directed consideration of the role of infrastructure and the impacts of changing temperatures on energy use.

Sensitivity to climate

4.33 The changing climate may indirectly alter the supply and demand of goods and services, both in the Scotland and further afield. Relationships between business operation and the impact of climate change on market share are currently highly tentative and disentangling the influence of other socio-economic changes makes identifying causal relationships problematic. The most comprehensive assessment of the economic impacts of climate change in the UK remains the study *Economic Impacts of the Hot Summer and Unusually Warm Year of 1995* (Palutikof *et al.*, 1997).

4.34 The sensitivity of Scottish business to climate impacts falls into two categories: impacts on specific business operation and impacts affecting business use of land and infrastructure. The service industry, which contributes two thirds of Scotland's GDP and three quarters of its workforce is, in general, less sensitive to impacts of climate change on specific business operation than other sectors. At industrial or manufacturing plants, the *Scottish Implications Scoping Study* noted sensitivities such as:

- The increased risk of infringing regulatory emissions of Volatile Organic Compounds (VOCs) from some chemical and pharmaceutical firms in warmer weather;
- The additional cost of treating waste-water at industrial facilities under conditions of more intense rainfall events;
- The increased energy costs associated with maintaining temperature-controlled environments, such as those found in semi-conductor manufacturing plants.

4.35 The sensitivity of Scottish businesses to impacts affecting land use and infrastructure reflects similar concerns to other sectors over any storm or flood damage.

Options currently employed to manage climate impacts

4.36 Respondents to the Scottish Implications Scoping Study noted many opportunities as well as threats from direct climate impacts, such as lower energy bills. The extent to which planned changes are appropriate depends to a large extent on the variability of future climate and the magnitude of change. Incremental changes in business operation are likely.

4.37 Climate impacts on specific business operation is rightly the responsibility of business. However, it is in the public interest for public authorities to develop tools to assist businesses to understand climate impacts. The UK Climate Impacts Programme seeks to raise awareness and educate business leaders to ensure that businesses can respond flexibly to climate change.

4.38 Options for responding to impacts on the business use of land and infrastructure, which are primarily through storm damage and flooding, concern issues of land use planning, building regulations and flood prevention schemes. These generic issues are considered in more detail later in the report.

Who pays?

4.39 Ultimately, the consumer will pay for the cost to business for adapting to climate impacts. The key decisions for business will be to ensure an appropriate level of protection from potential climate impacts, whilst maximising their profits.

Adaptation strategy for the business sector

4.40 Business must undertake their own analysis of the risks and opportunities entailed by climate change on their activities, with reference to the generic adaptation objectives of developing increasingly robust infrastructure design and increasing the flexibility of vulnerable managed systems. Vulnerability to climate impacts are primarily a matter of an increased risk of infringing existing environmental regulations, such as the air and water emissions monitored by the Scottish Environment Protection Agency, or of increased costs associated with use of infrastructure or energy. Market opportunities, particularly associated with reducing greenhouse gas emissions, will develop both nationally and internationally.

4.41 An effective adaptation strategy requires that society is prepared and aware of the issues it faces. It is in the public interest for public authorities to continue to provide timely information on likely climate impacts and enable appropriate planning by business. Perhaps

the most fundamental role for public authorities is to ensure that the planning system and building regulations support developments that are environmentally sustainable.

Adaptation Priorities

4.42 The diverse nature of the business sector and the likely climate risks it faces suggests that the adaptation priority lies with the provision of timely information on likely climate impacts and opportunities for business to minimise any possible disruption.

TOURISM

4.43 Tourism is one of the most important industries in Scotland and employs 1 in 12 of the Scottish workforce and 1 in 8 in the Highlands. Climate provides part of the environmental context in which tourism takes place. For this reason, we consider tourism in a little more detail.

4.44 The Scottish Tourist Board is undergoing far-reaching changes in response to a management review in 2000. It has been renamed VisitScotland and is undertaking a restructuring of its operations, which will be completed later in 2001. This reinvention of the Scottish Tourist Board reflects the fresh impetus the Scottish Executive has brought to position tourism at the centre of the economic development process (PWC, 2000).

4.45 VisitScotland have produced position papers exploring the global and social trends affecting tourism in Scotland (STB, 2000). These detail the myriad factors and issues that determine the popularity of Scotland as a tourist destination in the existing cash-rich, time-poor, educated society. Examples include:

- Decrease in leisure time;
- Patterns of increasing short breaks;
- An overall ageing population;
- Changing social structure towards one-person households;
- The need for Scotland to be at the forefront of new media technologies;
- The need for accessibility on short-haul flights from Europe and England to Scotland;
- Awareness of green issues.

4.46 Visitor surveys provide an assessment of the attractions and irritations of Scotland. Contrary to local belief, the weather was found to be either a positive or neutral aspect of Scotland for many visitors. Whilst 'good weather' was welcome, the visit to Scotland was rarely undertaken for the sole purpose of experiencing good weather. On the basis of such surveys, respondents to this study from VisitScotland were of the opinion that the climate was not a main determinant of decisions to visit Scotland.

4.47 An adjoining consideration is the increasing emphasis being placed on "green issues". VisitScotland has identified a clear marketing opportunity for Scotland to promote the perception of Scotland as a country with a pristine environment. The increasing focus on niche markets, such as golfing or the city break market, also reflects the changing social and global trends. Factors such as the strong exchange rate and high fuel prices, or alternative

events such as the football World Cup in France in 1998 all play a key role in determining visitor numbers.

4.48 The examination of tourism and climate change undertaken as part of the European *Acacia Project* (Parry, 2000) suggests that:

- The international dimension of tourism is sensitive to changes in climate that alter the competitive balance of holiday destinations;
- Higher temperatures and a longer season are likely to stimulate further tourism and recreational activities in northern European countries;
- Winter sports across Europe will be increasingly at risk from shorter seasons and unreliable snow cover;
- Climate changes are unlikely to be the major driving force in altering recreation and leisure patterns, which will be strongly influenced by social, economic and cultural changes.

Adaptation Priorities

4.49 This analysis suggests that in the short to medium term climate change will not have a major detrimental impact on Scottish tourism, apart from the reduction in winter sports, and may provide further opportunities to stimulate tourism. Harrison *et al.* (2001) consider in more detail issues of snow-lie in Scotland, which has implications for the viability of Scottish skiing and associated infrastructure. Harrison *et al.* (2001) argue that the adaptation priority is for diversification within the industry and the encouragement of more opportunistic short-stay holidays when snow conditions are good.

4.50 This analysis is at odds with the conclusion of the study, *Potential adaptation strategies in the UK*, which suggested that tourism in the UK would be significantly affected by climate change (ERM, 2000). This dissimilarity perhaps reflects the different reasons visitors have for visiting Scotland compared with England.

INSURANCE

4.51 The insurance industry is critical to climate change adaptation, since it provides one of the more accessible forms of adaptive strategies available to individuals and businesses. The viability of the insurance industry is a separate issue that depends on its ability to forecast and correctly cost the risks associated with climate impacts.

4.52 This study draws attention to some of the key insurance industry issues, drawing primarily on the report, *The Implications of Climate Change for the Insurance Industry* (Crichton, 2001).

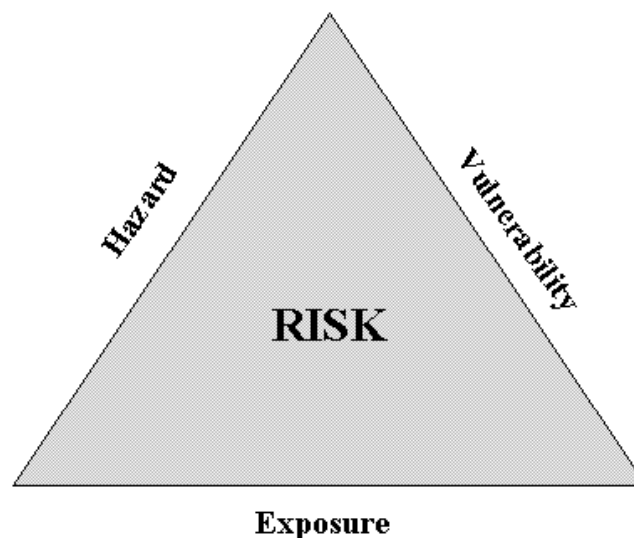
4.53 If, as expected, more natural catastrophes occur as a result of more adverse climate impacts coupled with higher numbers of people living in high risk areas, then the insurance industry will be one of the first sectors of the economy to feel the effects. This could have implications for other financial sectors such as the health insurance and life and pensions businesses. Insurance is a huge industry: globally, insurers hold a third of global stock worth £10 trillion in value (Crichton, 2001).

4.54 Traditionally, insurers can take four adaptive options (Parry, 2000):

- Pricing – raising the cost of policies;
- Risk transfer – into other financial markets;
- Limitation – limiting cover of some policies;
- Loss control – requires stakeholder engagement.

4.55 It is clear that insurers must be better able to identify and cost the risks associated with climate change. Ongoing work under the auspices of the Association of British Insurers (ABI), academic research, and Government agencies such as the Scottish Environment Protection Agency, seeks to improve the costing of climate risk. The insurance industry describes the issues under the risk triangle: hazard, exposure and vulnerability (see figure 4.2). The presence of all three is necessary for climate risk. If the hazard from climate impacts is increasing, action is required to reduce/minimise exposure to the hazard or to reduce vulnerability by improving adaptive capacity.

Fig. 4.2 The risk triangle of the insurance industry



4.56 Insurers can reduce their exposure to the risk of climate change by both improving their capability for insuring climate risk and proactively seeking to reduce the exposure to risk of institutions and individuals. Improving their capability requires building on their strengths of expertise in managing risk and minimising their weaknesses, such as inertia to change and a poor grasp of these longer-term issues. Reducing the individual or institutional exposure to climate risk requires action to influence public authorities and thus improve building standards, educate individuals on the implications of living in hazardous areas; and improve design and maintenance standards for flood defences and flood warning systems.

4.57 Insurers play a dual role in this process. Insurers need to take action to defend themselves against the adverse impacts of poor underwriting of climate risk. This will take place against the familiar ‘under-writing’ cycle when, in times of profit, capital is attracted to

industry, capacity increases, and as a result prices fall until losses result in a reduction of capacity as weaker insurers drop out. Crichton (2000) argues that this underwriting cycle is likely to be different in future because of structural changes in the financial markets.

4.58 The second role concerns the business opportunities that will arise for insurance companies as businesses and individuals seek to insure themselves against climate risk. Such opportunities reflect the advantages to businesses and individuals of managing some of their climate risk through insurance policies.

4.59 One approach of the insurance industry to minimise its exposure to climate risk is to apply limits to their policy cover. Vulnerability to flood risk, for example, is geographically very specific. The insurers have the capacity to withdraw cover if a development takes place against the advice of insurers or reduce their liability. For example, the Flood Prevention and Land Drainage (Scotland) Act 1997 requires biennial reports to be prepared by Local Authorities to specify measures they should take to prevent or mitigate flooding of land in their area and all occurrences of flooding of such land since their last report. Crichton (2000) argues that if a local authority allows a development and fails to maintain a watercourse for which it is responsible and which subsequently floods the development, the insurers would have a strong legal case for financial redress from the authority. This assertion, however, has not been tested in court.

Adaptation Priorities

4.60 It is clear that any climate adaptation strategy developed by public authorities must explicitly interrelate with the insurance industry, both to provide an accessible strategy for adapting by businesses and individuals and to ensure a healthy insurance industry. The use of insurance representatives on Flood Appraisal Groups, which assist local authorities with practical guidance and information on flood risk and its development implications, provides a good example of informal co-operation and should be encouraged.

TRANSPORT

4.61 This section considers the existing framework for managing climate risk in the rail and road sectors. The Scottish Implications Scoping Study noted that climate change can present an important business risk to transport infrastructure in Scotland. Operational matters for transport operators are not considered in this report.

Roads

4.62 Responsibility for the trunk road system lies with the Scottish Executive, which accounts for 6% of the total of over 53,000 kilometres of public road, while local authorities are responsible for the remainder.

4.63 Responsibility for the maintenance of the trunk road network now lies with four Operating Companies under 5-7 year contracts. These contracts include professional and managerial services as well as work such as patching road surface and repairs, gully emptying, salting and snow-removal.

4.64 The physical condition of motorways and trunk roads is monitored by annual condition surveys that are undertaken by specialist contractors. The surveys are designed to provide information about the structural, surface and safety condition of the road. The data from the surveys is processed annually in a pavement management system so as to identify performance objectively and to target the available funds on those areas of greatest need.

4.65 Modern construction of roads has a design life in the range of 20-40 years. Associated drainage design should provide an equivalent life with appropriate maintenance, whilst structures such as bridges are designed to last 120 years. In practice, the rate of deterioration of a road will depend on the volume and weight of traffic using it relative to that assumed in its design. Respondents to this study suggested that weather related disruption to road networks through land-slips may be indicative of design omissions or poorly maintained drainage. The quality of the ongoing maintenance is clearly very important. Design of roads and bridges adheres to the formulations defined in the *Design Manual for Roads and Bridges* (a continuously updated publication prepared by the Highways Agency, the Scottish Executive, the Welsh Assembly and the Northern Ireland Assembly). At present this specifies that the design of new roads in flood plains should investigate the constraining effect of the road and bridges against conditions that are exceeded on average once in 100 years. In Scotland, the views of SEPA on this flood return period should be taken into account and the vulnerability of any areas subjected to flood should also be considered. More generally, the drainage of the road surface itself should ensure that the carriageways are not subject to flooding on average more than once in 5 years.

4.66 The marginal cost of inserting drainage schemes designed for larger water volumes than present is negligible for new build. The cost of replacement of existing infrastructure across Scotland would be hugely expensive.

Vulnerability of road sector

4.67 The *Scottish Implications Scoping Study* suggested that the road network is most vulnerable to increased intensity of precipitation and the consequent increased risk of flooding. Respondents to this study noted that there was no evidence that flooding on the road network has worsened in recent years. This concurs with the evidence about flooding occurrences in Scotland noted by Price and McInally (2001).

Existing options for managing climate impacts

4.68 The existing pavement management system provides the main approach for analysing maintenance intervention needs of the road network based on an annual cycle of surveys. The Operating Companies also have a duty to maintain an ongoing knowledge of the operational condition of the network and would respond quickly to emergencies which threaten to block or restrict the carriageways.

4.69 Flooding raises the same issues as disruption of the road network from winter snow. Under these conditions, attention to the road network is prioritised to ensure that the public are inconvenienced as little as possible in their use of the network. Throughout Scotland variable message signs are able to divert traffic from impeded routes at strategic points of the network. The NADICS Control Centre in Glasgow provides a Website on which it can post information about the whole of the trunk road network and supply information to radio stations for broadcasting.

4.70 Alternative options for reducing flood risk associated with road developments include the development of upstream attenuation systems to reduce the likelihood of flooding. Such approaches raise the issue of land purchase associated with road development and the need to zone land use on either side of the roads. The development of Sustainable Urban Drainage Systems (SUDS) by SEPA provides an example of more sustainable approaches to road drainage in urban areas.

Potential adaptation strategies

4.71 With respect to the generic objectives of an adaptation strategy, the road system requires robust infrastructure design with a capacity to adapt to the changing flood risk. The changing climate will not change the need to cope with cold winters for the foreseeable future. The existing management structures appear to be an appropriate mechanism for monitoring and identifying the changing flood risk, as it becomes apparent in Scotland. Enhancing the capacity to adapt should focus on the guidelines within the *Design Manual for Bridges and Roads* and on the advice given by SEPA on appropriate design specification of flood drainage from roads. Integration of information available from the implementation of the Water Framework Directive is likely to prove helpful to this process.

4.72 One approach to taking a wider view of road development and existing drainage schemes is to develop zoning of land use on either side of roads to better attenuate flood risk. Such schemes have already been considered in the context of landscaping for road schemes. More recently, carbon offset schemes have used the same principle to mitigate the emission of greenhouse gases from the transport sector.

Rail

Existing management framework

4.73 Responsibility for managing the Scottish rail system lies with the train operating companies (TOCs) in association with the owner and manager of the railway assets, Railtrack. The main franchise holder in Scotland is ScotRail which operates 95% of Scotland's rail services. Other franchise operators in Scotland include GNER, Virgin West Coast and Virgin Cross Country. The current ScotRail franchise ends in 2004 and the process for its re-letting is now beginning. It is likely that the new franchise will operate for 15-20 years. Rail freight companies operating in Scotland comprise EWS and Freightliner.

4.74 DEFRA and the Strategic Rail Authority (SRA) oversee the strategic context of the railways. The SRA was set up by Government to provide a focus and strategic direction for Britain's railways, to encourage investment and manage the passenger rail franchises. Currently it is engaged in a process of replacing these franchises, with the aim of increasing capacity and improving the overall service to the customer. The railways are expected to receive up to £60b funding from public and private sources in the next 10 years. Of this, about £50b is expected to be in the form of capital expenditure on the infrastructure.

4.75 The 1998 Railways Act reserves powers at Westminster for the rail system through the Strategic Rail Authority (SRA), but under the devolution settlement, the Scottish Executive may provide Directions and Guidance to SRA on franchises for rail services which begin and end in Scotland. The Executive can also provide advice to SRA for franchises for Anglo Scottish services such as for the East Coast Main Line.

4.76 Safety on the railways is the responsibility of Railtrack and the Train Operating Companies, for which they are held to account by Her Majesty’s Railway Inspectorate (HMRI). HMRI regulates railway safety and carries out accident investigation. The SRA has no locus in safety matters.

Current sensitivity to climate impacts

4.77 Railtrack Scotland has identified adverse weather as a key business risk. Adverse weather has severe commercial implications both in lost revenue and capital costs for infrastructure repair. The main climate sensitivities include (Kerr *et al.*, 1999):

- Flooding;
- High winds, interfering with the connection between the overhead line and the train.
- Fallen leaves, particular wet leaves in autumn;
- Large temperature range stresses and fracturing rail lines.

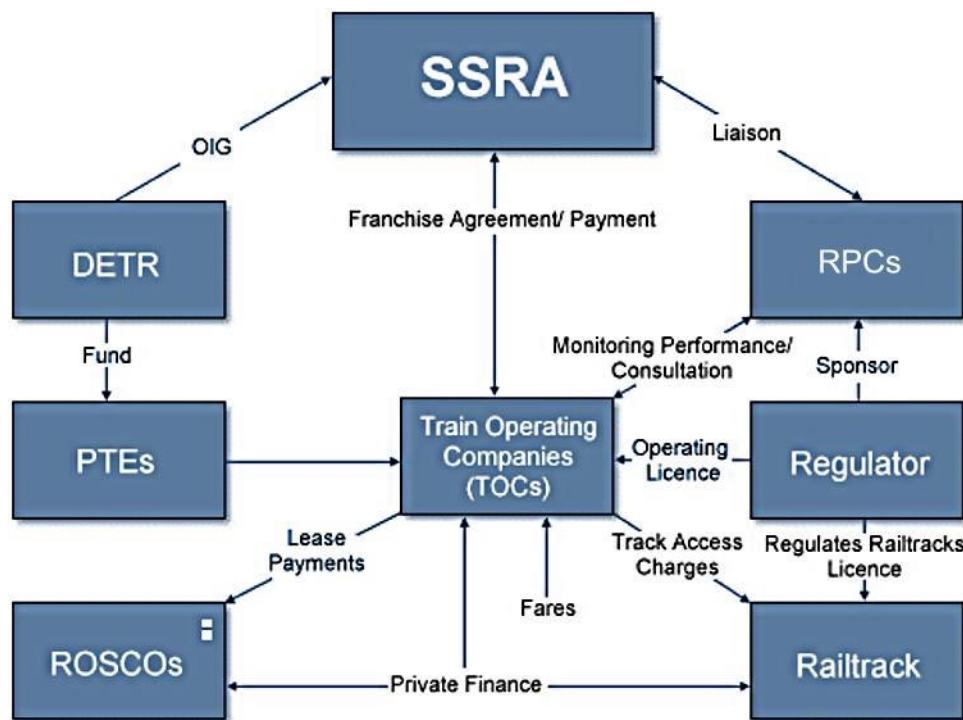


Fig 4.4 Principle responsibilities within the UK rail network (from SRA)²

² ROSCOs are rolling stock companies; PTEs are passenger transport executives; RPCs are rail passenger committees; SSRA is the Strategic Rail Authority.

Existing options for managing climate impacts

4.78 Respondents to this study suggested that the fragmented nature of the industry has not lent itself to strategic thinking. This has led to a blame culture in which it has been difficult to balance the needs for a financial return with the financing required to maintain robust infrastructure. The Government set up the SRA to address these strategic issues.

4.79 Railtrack Scotland is currently identifying sites that are vulnerable to flooding and installing pumps and/or culverts. At present, rapid response teams are employed to clear drains or divert floodwater away from railways in emergencies. Such reactive emergency response measures are very expensive. The prospect of a significantly changed climate would require a reassessment of approaches to tackle such events. Railtrack Scotland also works with the National Farmers Union (Scotland) to encourage actions on land adjacent to railways that reduce flood risk.

4.80 Operational issues associated with adverse weather impacts needs to be addressed by individual train operating companies in conjunction with Railtrack. It is obviously in their interests to build such risks into their business plan, once they have identified the most detrimental aspects of the changing climate.

Potential adaptation strategy for the railways

4.81 In common with the road system, an adaptation strategy for the rail network requires robust infrastructure design, coupled with a capacity to adapt to the changing climate risk, specifically flooding and storm damage. The tenuous nature of much of the rail network in Scotland results in inherently more vulnerability than the road system, and this vulnerability needs to be reflected in larger safety margins.

4.82 In common with the energy supply and water service sectors, the key issue concerns the ability of the Strategic Rail Authority (SRA), the rail regulator, Railtrack and the train operating companies to agree an acceptable balance between financing required modifications to the infrastructure and the cost to the customer. In seeking to improve the level of capacity across the network, the SRA is involved in a number of projects aimed at opening up capacity bottlenecks and expanding the capacity of the network. For example, the SRA is closely involved in the current multi-billion pound upgrade of the West Coast Main Line's infrastructure and signalling.

4.83 Perhaps equally important will be the competing interests across the UK network. It remains to be seen whether the cost of protecting some of the Scottish railways, particularly in the rural areas where demand is relatively small, will be deemed a priority by a GB-wide strategic rail authority. Much then depends on the capacity of the Scottish Executive to influence the SRA on the wider issues of social inclusion and integrated transport beyond strict cost-benefit analysis.

Transport Adaptation Priorities

4.84 The railway network is more vulnerable than the road network to climate disruption and should be considered a priority for adaptive measures. As with the energy and water supply industries, a key issue concerns the necessary finance to minimise cost-effectively the climate-related disruption to the railway infrastructure. This requires co-ordinated efforts

between the main industry players and awareness building with the travelling public. Landscape zoning is already practised on the transport networks and provides a useful benchmark for working with local landowners. The implementation of the Water Framework Directive provides an opportunity for more strategic overview of catchment flood risk.

DOMESTIC

Existing management of climate impacts

4.85 Housing is a high profile issue for the Scottish Parliament. This section encompasses both public and private sector housing. Numerous interwoven factors affect this sector, such as poor housing stock, fuel poverty, public health and improving energy efficiency. While the changing climate is not one of the key drivers in managing this sector, it will have an adverse impact on some dwellings particularly if exposed to driving rain, increased storminess, or coastal/riverine flooding (Kerr *et al.*, 1999).

4.86 Owners of land and property have primary responsibility for coping with the adverse impacts of climate.

Existing policy framework

4.87 Public authorities provide the framework of building controls and local planning guidelines that seeks to minimise (but not remove) the risk of damaging climate impacts on housing. The planning controls are considered in more detail in the Public Sector section of this chapter.

4.88 The origins of the current system of building control lie in the Guest Report of 1957. The report argued that the purpose of building control was to be the protection of the public interests as regards health and safety. These recommendations were accepted, and as a direct result the Building (Scotland) Act 1959 was passed. The first set of Building Standards (Scotland) Regulations under the Act was made in 1963, and came into force in 1964.

4.89 The responsibility for making the regulations was devolved to Scottish Ministers in 1999 and the Scottish Executive is responsible for preparing and issuing the Technical Standards for compliance with the regulations. The responsibility for the administration of building control was originally given to, and remains with, local authorities.

4.90 The building control system is essentially pre-emptive. It is based on the principle of identifying problems at the design stage, so that the building can be built to a set of plans which have been approved and for which a warrant has been issued. There is provision for inspection during the construction process to help the local authority determine whether the building is being constructed in accordance with the warrant. The onus is on the property owner to comply with the regulations, not the builder.

4.91 Building regulations in Scotland have had provision for conservation of fuel and power since the coming into force of unified Building Standards Regulations in 1964. Initially, the requirements were aimed at the minimisation of problems of condensation and dampness in housing. Subsequently, the requirements were aimed at reducing the

consumption of fuel and power on the grounds of cost and, more recently, to raise the energy conservation standards for environmental reasons.

4.92 It is important at the outset to be clear about what the building regulations can, and more importantly, cannot do. The Scottish building regulations consist of three elements:

- The Building Standards Regulations themselves, which are mandatory functional statements;
- Technical Standards, which are mandatory requirements to support the Building Standards Regulations; and
- Deemed-to-satisfy specifications, which in turn support the Technical Standards, the use of which is not mandatory but where they are used, must be used exactly as specified.

4.93 The building regulations set minimum standards for construction and are not intended to be manuals for good practice for either design or workmanship. Substantial energy savings can be achieved through the introduction of higher building standards for energy conservation. However, the two aspects that have a considerable influence on the building's performance, design and workmanship, are largely outwith building control and are the responsibility of the architect and the builder.

4.94 Part J of the Technical Standards for compliance with the Building Standards Regulations deals with the conservation of fuel and power and was last amended in 1997. Critically, that amendment introduced a third aspect, that of reducing CO₂ emissions into the atmosphere through energy conservation. A further amendment is currently subject to consultation and will considerably reinforce this third aspect.

4.95 Buildings account for almost half the UK energy consumption and a similar proportion of energy related CO₂ emissions. The aim is to maximise the contribution that building regulations can make to meeting the Government and the Scottish Executive's CO₂ commitments, while ensuring that the proposals are practical and can be incorporated into normal building practice without excessive cost increases or technical risks. The proposed amendment is expected to improve the thermal performance of buildings by approximately 25-30% with a corresponding reduction in CO₂ emissions.

Existing sensitivity to the climate

4.96 The report, *Impact of climate change on construction* (Garvin *et al.*, 1998) remains the most comprehensive examination of climate impacts on buildings in the UK. The authors highlight areas that will be affected by potential impacts:

- The Construction Process, including health and safety issues; material use; site storage of materials; site soil conditions; site flooding; weather delays; and problems with plant;
- The Building Fabric, including storm damage; geotechnical problems; metal corrosion; timber, plastic and rubber degradation; concrete durability; masonry cracking; flood damage; and rain penetration.
- The Internal Environment and Energy Use including internal temperatures/comfort; energy consumption; condensation and mould growth; internal pollution; and health problems.

4.97 Respondents to the *Climate Change: Scottish Implications Scoping Study* noted that Scottish housing stock is designed to cope with the prevailing wet and windy weather of Scotland (Kerr *et al.*, 1999). Respondents to this study considered that Scottish buildings generally cope with the present climate, though substantial increases of persistent or driving rain may cause problems. The current standards have substantial ‘head-room’ built-in for extremes of weather.

Existing options for managing climate impacts

4.98 The most common approach to managing climate impacts remains through the insurance system. Unfortunately, the existing framework tends to emphasise the transfer of responsibility from the owner to the insurer, rather than the existence of a partnership for maintaining the quality of infrastructure (Garvin *et al.*, 1998).

4.99 In practice, the most effective means of managing climate impacts remains ensuring regular professional inspection of roof structures and main walls. Housing in poor repair is disproportionately concentrated in pre-1919 urban and rural stock in both the owner occupied and private rented sectors. Greatest numbers of dwellings in poor repair are found in the urban owner occupied pre-1964 sector, the urban public rented 1919-64 sector, the urban private rented pre-1919 sector and the rural owner occupied pre-1919 sector.

4.100 At present, a number of Parts of Technical Standards are revised at each amendment. These amendments occur about every two years, and each Part is probably considered at least every third or fourth amendment. This may mean that it is six or eight years between revisions of individual sections. This procedure provides a mechanism for developing climate-related building controls for new stock. However, the issue of how to apply building controls retrospectively on existing housing/buildings that will have a lifespan of perhaps over 100 years remains unresolved.

Potential adaptation strategies

4.101 The objective of a generic adaptation strategy is to ensure robust infrastructure coupled to the capacity within the building control system to adapt to the changing climate. The framework for regularly revising building standards is in place and the consultative Building Standards Advisory Committee (BSAC) has expressed its interest in and noted the strategic nature of the climate impacts issue. BSAC is the statutory body charged with advising the Scottish Executive on the content of regulations and the operation of the system. The committee has 14 members who comprise a cross-section of those involved in the building control process. The full committee meets three times per year, but much of its work is done through sub-committees that play a significant role in reviewing and revising particular parts of the Technical standards. While BSAC provides a valuable oversight of the system and the proposed amendments to standards there is no other monitoring of building control.

4.102 However, the majority of people own properties not built under recent building regulations and must continue to invest in maintaining the condition of the property. It is in the public interest for public authorities to alert these property owners to the appropriate means of reducing the detrimental impact of weather on their properties. Use of existing Government schemes to improve energy efficiency could be adapted to alert owners to issues associated with likely climate impacts.

4.103 Local planning guidance is considered in the next section. The development of more specific insurance policies that reflect the foreseeable risks of the locality could be an important factor in reducing the transfer of responsibility from property owner to insurance company. Information on building risks, such as the potential for flooding or subsidence, is available in England and Wales on the internet and such tools are likely to be developed in Scotland before long. They provide a powerful tool for informing the public of the climate (and other) risks within the local area.

4.104 Specific consideration of topics such as embodied energy and the use of timber-framed buildings will continue as part of the drive for more sustainable buildings in Scotland. Studies have already considered the extent to which the principles of sustainability could be enforced through the building control system and the associated impact of climate change. The development and administration of the existing Building Standards is currently undergoing a review to explore means of raising the standards of Scottish buildings, for access and the environment, to allow greater flexibility by designers, whilst reducing the red tape associated with administering the system.

Adaptation Priorities

4.105 The priority in the domestic sector appears to be awareness raising by public sector bodies about appropriate means of reducing the detrimental impacts of weather on their properties and the implications of more geographically specific insurance policies that reflect the foreseeable risks of the locality.

PUBLIC SECTOR

4.106 This section considers adaptation strategies for local authorities, the planning guidance provided by public authorities; the water services industry, which remains in public ownership in Scotland; and health and education issues.

Local Authorities

Existing management of climate impacts

4.107 Local authorities provide one of the cornerstones of adaptive management to climate change in Scotland. They are responsible for the development of structure and local plans, which set out the future development and use of non-agricultural land, and retain discretionary powers to put flood prevention measures in place. Local authorities also own substantial estate that may be exposed to climate risk.

4.108 Work by the Scottish Executive to influence action on climate change issues by local authorities has focused on measures to reduce the emission of greenhouse gases. In practice, there is much overlap between the need to improve the quality and energy efficiency of housing and the need to improve its capacity to cope with adverse climate impacts. For example in 2000, the then Minister for Transport and the Environment, Sarah Boyack, MSP, announced funding through the Healthy Homes Initiative to tackle dampness in up to 80,000 council houses as part of an overall package to improve energy efficiency.

4.109 The "Taking Ownership" seminar organised by CoSLA, the Energy Savings Trust and the Scottish Executive explored ways in which local authorities could reduce emissions of greenhouse gases and deal with the anticipated impacts of climate change (Scottish Executive, 2000a). Local authority participants suggested that maintenance of buildings to an acceptable standard was a real problem. A mandatory asset condition survey is needed to identify buildings surplus to requirements and those in urgent need of maintenance. The opinion of some of the local authority representatives was that they were simply 'fire-fighting' and did not have the resources to proactively tackle maintenance of their estate to meet even the existing climate risk. Other participants commented that devolving funding below the level of local authorities simply exacerbates the problem of the lack of strategic oversight. Some protagonists argued for example that in many cases less than 50% of money devolved to schools for maintenance is actually spent on maintenance.

4.110 The Flood Prevention (Scotland) Act 1961 provides local authorities with discretionary powers to put flood prevention schemes in place. Nevertheless, flood prevention historically has had a lower profile than it has, for example, in England and Wales. Geography plays a part in this because rivers characteristically are shorter in Scotland, with smaller areas at risk from flooding much of which in the past has been agricultural land. Flood prevention for agricultural land is the responsibility of the landowner. No substantial coastal flood prevention activity exists in Scotland, although the recent establishment of Coastal Fora has begun to focus attention on this issue.

4.111 The main driver for the development of a flood prevention scheme by a local authority has been in response to a flood that has recently happened. The local authorities determine whether and where the flood prevention scheme takes place, usually on the basis of past flooding and levels. By using statutory powers, local authorities can build flood protection schemes on land not belonging to them.

4.112 The design of the scheme is usually required to meet a 1% risk of flooding in any one year and include some element of freeboard, which is additional capacity, that may reduce the probability of flooding towards 0.5% in any one year. Often, the size of the last major flood provides the justification for the particular design of the scheme. Recent examples of flood protection design, at Perth and Kelvin, use a 0.56% risk per annum.

4.113 The statutory process for developing a flood prevention scheme can take between one and three years depending on any objections which, unless they are withdrawn, force a local enquiry. The financing of flood prevention schemes is separate from the statutory process, though in practice they are often processed together to avoid the potential political fall-out from having offered political assent to a project without necessary funding. The Scottish Executive provides 50% of the funding for schemes that meet its requirements and where the cost-benefit ratio can be shown to be greater than 1. Local authorities need to justify their design scheme, for example to meet the 0.5% flood risk, and undertake a cost-benefit analysis over 60-80 years. The Scottish Executive can advise if the scheme design is insufficient and ultimately refuse funding, but the decision on design specification remains with the local authorities.

4.114 Funding for flood prevention has been running at around £4m per annum in Scotland and, interestingly, has been under budget in recent years. It has now been increased to £27.5m over 3 years from 2001. Funding for flood prevention in England and Wales has an incidentally beneficial effect in Scotland as ~10% of the funding comes north of the border.

There are at least 50-60 Scottish flood prevention schemes under consideration at present that could be funded in the next few years.

Sensitivity to climate

4.115 Unfortunately, information is not available on the area of land in Scotland at risk from river flooding. Maps used for coastal protection are equally lacking in topographic and hydrographic detail. It is therefore impossible at present to assess properly the sensitivity of increased flood risk in local authority areas.

4.116 On the basis of the existing climate scenarios, the local authority estate is particularly sensitive to the expected increases in rainfall. Dampness is already a major problem and, for buildings in disrepair, is likely to worsen in the future. The climate scenarios are ambivalent about any increase in the intensity of storms, which might lead to infrastructure damage. Sea level rise will have an adverse impact on the relatively small number of exposed dwellings in coastal towns and villages.

Flooding and Probability

Flooding is a natural phenomenon that plays an important role in shaping the natural environment. It is not possible to remove the risk of flooding entirely from land within the flood plain of a watercourse or adjacent to tidal waters. Society has reasoned that building on flood plains, comprising flat, fertile land, has advantages that outweigh the disadvantage of intermittent flooding. Accordingly, flood protection schemes are designed to a specified degree of risk of flooding. Flood protection schemes are not designed to remove all risk of flooding.

Unfortunately, the terminology associated with the probability of flood risk is often misunderstood. The degree of risk is calculated from historic data and expressed in terms of the expected frequency of a flood of a given magnitude. For example, the 10 year or 100 year flood. This means that there is a 10% or a 1% chance of such a flood in any given year. Over a longer period, such as the lifetime of a building, the probability becomes substantially greater.

For example:

A 100 year return period flood, which was a common design for flood protection schemes has:

a 1% chance of it occurring in any particular year; but
a 26% chance of one such flood in a 30 year period; and
a 51% chance of such a flood in 70 years.

In other words, if someone lives in a house that is protected with a flood defence scheme with a 1% risk (1 in 100 year return period), then over the course of that person's lifetime, there is a one in two chance of being flooded.

Information taken from NPPG7 Planning and Flooding. Scottish Executive.

Price and McNally (2001) conclude that the changing climate forecast for Scotland is likely to shorten these odds and thus reduce the effectiveness of existing flood prevention schemes.

Options for managing climate impacts

4.117 Issues associated with proposed changes to the building regulations are discussed in the Domestic section of this chapter. Perhaps more pressing, since the turnover of stock in Scotland is of the order of 1% per year, is to improve the repair of the existing local authority stock.

4.118 The Scottish Climate Change Programme details initiatives such as the New Housing Partnerships and Warm Deal that seek to promote community ownership, secure additional investment in housing and improve home insulation. Whilst the main drivers for these initiatives are not climate change, nevertheless they provide a vehicle to improve the quality of housing stock and also reduce greenhouse gas emissions.

4.119 Related initiatives include Scottish Homes' sustainable development policy that seeks to improve the environmental performance and sustainability of Scotland's homes and the Home Energy Conservation Act (HECA).

4.120 When planning a flood prevention scheme, local authorities make extensive use of external consultants, who have a good knowledge of practical options. Where flooding occurs in urban areas, flood-walls are often required, though where more space is available flood banks can be used. Increasingly, upstream flood attenuation schemes are being developed, such as ponding and use of reservoirs. Buying land upstream or other arrangements may be required for these schemes.

4.121 At present, SEPA is required when requested to provide information it holds on flood risk to a local authority. However, catchment data is often poor or non-existent. Flood maps developed by the UK Centre for Ecology and Hydrology (CEH) are often used as a first marker for councils.

Potential adaptation strategies

4.122 The key issues for an adaptation strategy for local authorities revolve around ensuring robust infrastructure coupled to a programme of building awareness about flood prevention. Local authorities argue that delivering appropriate investment for the maintenance of building stock is a problem. The primary strategic strategies for improving flood prevention include:

- Improving public awareness about what a flood prevention scheme can and cannot do - it cannot stop all flooding all the time;
- Knowing how much and what type of land use is at risk. National Planning Policy Guideline 7 (NPPG7) on flooding provides a robust framework to stop new flood hotspots developing. Nevertheless, respondents to this study suggested that Councils' are under conflicting pressure to use unsuitable land for development.

4.123 It appears that the recent spate of flood defences built in Scotland is only just keeping abreast of flood hotspots that resulted from previous planning decisions, which are now perceived to be flawed. This response is primarily reactive. As such the system copes reasonably well and the designs are now required to consider the implications of climate change predictions on top of the design standards that have recently been accepted (a minimum of 1% risk). Presently, designs are beginning to anticipate flexible responses, for example providing foundations that will accept larger flood defences if required in future.

4.124 The need for good flood risk data becomes more important as the system becomes more proactive, in other words when forecasting flood-events rather than reacting to them. The implementation of the Water Framework Directive provides an opportunity for better understanding of catchment water abstraction and control. Issues of sustainable development are important and must be integrated into the flood prevention schemes from an early stage. Sustainable solutions to flooding problems should, for example, involve examining options for the upstream catchment.

Existing policy framework

4.125 The planning system exists to determine the future development and use of land. It influences the location, form and extent of development, which generates demand for and responds to transport infrastructure. These in turn are the major influence on energy use, emissions of greenhouse gases and other waste products. Planning plays a major role in the protection of natural resources, of habitats and biodiversity. Yet appropriate development is essential for job opportunities and for the economic and social renewal of communities. Ensuring that planning policies are aligned to achieve sustainable development objectives is critical to the quality of life and the quality of our common environment (AGSD, 1998).

4.126 Decisions are usually best taken at a local level, so local authorities are responsible for producing development plans, which comprise a structure plan and a local plan, in consultation with local people and organisations. Between them the plans show how much development will take place, where it will take place and where it is unlikely to be allowed.

4.127 The role of the Scottish Executive is to:

- Maintain and develop the law on planning;
- Give policy guidance and advice;
- Approve structure plans; and
- Make decisions on some major planning applications and all appeals.

4.128 A series of National Planning Policy Guidelines (NPPGs) sets out national policy on land use and other planning matters. Important examples include the recent revision to NPPG 6 on the planning issues relevant to the development of renewable energy.

4.129 The Royal Commission on Environmental Pollution (RCEP) is undertaking a major study of Environmental Planning in the UK and plans to report its findings later in 2001. This study intends to cover topics such as how democratic control should be exercised over land use decisions; the potential conflict between national environmental strategies and local interests; private versus public rights; and the resilience of the existing arrangements to cope with foreseeable developments such as climate change. It is unclear whether the RCEP report will consider the distinctive planning system and institutions in place within Scotland and the further divergence that is likely for policies on land use following devolution.

Existing policy framework

4.130 NPPG 7 on Planning and Flooding provides a lucid account of the role of planning in reducing the risk of flooding in Scotland. It provides guidance to planning authorities, developers and the public, which should ensure that decisions in relation to areas of existing and future development take account of inland or coastal flood risk. The guideline seeks to address the problems flooding can cause by:

- Emphasising that the susceptibility of land to flooding is a material consideration in planning decisions;
- Instructing planning authorities to act responsibly in the weight they accord to flood risk information;

- Stating that owners remain primarily responsibly for safeguarding their property;
- Explaining the lead role of local authorities in flood prevention works;
- Clarifying the role of the various agencies and statutory bodies in providing advice on flood issues (see Box 4.1);
- Applying the precautionary principle to decision making so that the risks are managed appropriately;
- Specifying the actions which planning authorities should take in their structure and local planning work and in development control;
- Improving the information available to the community about the risks of locating in an area susceptible to flooding; and
- Recognising that flood prevention measures can have implications for the natural and built environment.

4.131 NPPG7 covers many of the topics discussed in the draft PPG25 on Development and Flood Risk in England, though a future revision of NPPG7 might consider strengthening its strategic sense and ensuring that the link between developments and any consequent flood risk is adequately addressed by developers in perpetuity.

Sensitivity to climate change

4.132 NPPG7 comments on the changing risk of flooding that results from climate change (including any associated sea level rise) and the qualitative consequences of this change in terms of the rising probability of a flood event happening. The guideline briefly considers the mechanisms that lead to flooding from storm surges; coastal flooding; and river flooding. In addition, the guideline advises that the planning authorities should consult with insurance specialists about likely insurance cover prior to the initiation of any development.

4.133 Other climate impacts to which Scotland is particularly vulnerable include any increase in storm intensity, and thus damage to building infrastructure, which is the preserve of building regulations.

Existing options for managing climate impacts

4.134 There is no statutory duty for flood prevention schemes to meet designated design standards, not least because of the lack of good information on flood return periods for Scottish rivers. Instead, the guidelines argue that local authorities are in the best position to address local issues and concerns since they have responsibilities for flood prevention, planning and building control. Flood Appraisal Groups can be formed to provide the local authority with practical guidance and information on flood risk and its implications for development. These groups:

- Are concerned with measures to reduce flood damage;
- Are convened by the local authority;
- Should involve the relevant local authority departments and other relevant agencies with flooding responsibilities;
- Should involve relevant private sector representatives;
- Are informal and advisory only;
- Provide a forum for the various parties to reach a consensus view on flood risk and its consequences.

4.135 Respondents to this study believe that the flood appraisal groups at local authority level should continue to be supported by the Scottish Executive and should remain informal, since this enables a more inclusive and consultative process for considering flood risk.

4.136 SEPA retains an important role in reducing flood risk. SEPA must advise a local authority when a development entails flood risk. Under the General Development Procedure Order, if there is an increase in the material risk of buildings from flooding then SEPA must be notified. If SEPA raises a point of order, then the case is referred to the Scottish Executive for final approval. This process provides a powerful filter, since few authorities want to go through this statutory loop. If the local authorities have a financial interest or there is a national interest in the development, the Executive must also be notified. This process has also caught some cases of development at risk of flooding.

4.137 About 21 flood appraisal groups exist to assist local authorities. Such groups are encouraged but not required by the Scottish Executive.

Potential adaptation strategies

4.138 The key issues for a generic adaptation strategy reflect the need for infrastructure with the capacity to adapt to the changing climate and public awareness of the planning arrangements to reduce flood risk. NPPG7 provides the necessary framework to minimise flood risk for new developments. Perhaps the biggest weakness of the planning system is that it does not assess the cumulative impacts of different proposals. Planning decisions can be challenged legally, so there is a need for a robust framework of climate scenarios. Integrating a more strategic overview of catchment planning, such as will be provided through the Water Framework Directive, could assist planners. The use of flood appraisal groups, including insurance industry representatives is to be encouraged.

4.139 Planning and building control could work more closely together. At present, one often comes into conflict with the other. For example, attempts to improve thermal efficiency by building controls leads to conflicts with planning regulations. This is particularly the case when attempting to improve buildings retrospectively.

Owners of land and property	Have primary responsibility for flood protection and insurance.
SEPA	Maintains river flow records, operates flood warning systems, can provide information on extent of previous flooding.
Local Authorities	Have statutory powers under the Flood Prevention (Scotland) Act 1961 to prevent or mitigate flooding of non-agricultural land in their areas. Act on behalf of the wide public interest and can commission reports on flood risk and flood prevention. Maintained sewage treatment and water works that can be affected by flooding until April 1996 when these responsibilities were taken over by the new Water Authorities. Responsible also for emergency planning, coastal protection and for housing those made homeless by flooding and for remedial works to their own stock.
Scottish Executive Rural Affairs Department (SERAD)	Grant aid arterial drainage works, including flood protection, carried out by agricultural owners and businesses. Maintain Statutory Drainage Schemes carried out under the Land Drainage (Scotland) Acts 1930-1941 on parts of the Allan Water, River Almond, River Annan, River Clyde, Dean Water, River Devon, Goodie Water, River Kelvin, Lochty Burn, River Nith, Piltanton Burn and Loch of Park.
Also SERAD	Give grant aid to regional and island councils on specific flood prevention schemes submitted for confirmation. Provide advice to farmers on engineering aspects of flood protection and prevention projects. Have a co-ordinating role between central and local government on flood related issues. Responsible for co-ordination of pollution matters, advice on climate change/ozone depletion and monitoring Scottish Environment Protection Agency (SEPA).
Scottish Executive Development Department (SEDD)	Local Government Finance Division will administer Bellwin Scheme and co-ordinate relief in respect of flood damage with regional & island councils.
Scottish Executive Justice Department (SEJD)	Provide funding for emergency planning under the Civil Defence Act 1948, organise training studies and seminars.
Railtrack/ British Waterways Board/ Roads Authorities/ Riparian Authorities	May control river embankments/canals/land on flood plains. They may also have permitted development rights that can affect the level of run off.
Meteorological Office	Have role to play in flood prediction and warning of adverse weather conditions. Also has role in providing precipitation data to SEPA under agreement (Memorandum of Understanding).
UK Centre for Ecology and Hydrology (CEH)	Source of data on flood-risk and river flow/tidal records.
Risk Consultants/ Centres of Research	Can provide information on flood-risk assessment.
Insurance Companies	Have interest in assessing flood-risk for setting insurance policies and premiums.
Business Community	Often commercial/industrial property can be affected by flooding.
Scottish Natural Heritage	Must be consulted by planning authorities where arterial drainage or river works, or other proposals could affect a site of European importance (SAC or SPA), a SSSI or NNR.
Historic Scotland	To be consulted where works may affect a scheduled monument.
Scottish Power	Maintain power lines, electricity supplies.
Scottish and Southern Energy	Control discharge from hydro-electric reservoirs.
Police	Have primary role in dealing with flood events and emergencies.

Box 4.2 Responsibilities for dealing with flood hazard in Scotland (from NPPG7).

Water Services

4.140 The three publicly owned Water Authorities are being merged into one Authority within the next year to improve standards, efficiency and be better able to compete in the rapidly changing market. The following section draws on the workshop report, *The Water Industry - The Changing Climate* (Scottish Executive, 2000c).

Existing management of climate impacts

4.141 At present, the regulatory framework for the Scottish public water service is:

- The Scottish Executive has overall responsibility for the regulatory framework for the water industry and is responsible for ensuring compliance by the water authorities with specified drinking water quality standards;
- SEPA is responsible for ensuring that the Water Authorities comply with statutory (particularly EU) environmental protection standards;
- The Water Industry commissioner (WIC) is the economic and customer services regulator of the water authorities;
- The water authorities plan, provide, maintain and operate the water supply and sewerage services for their customers in Scotland.

4.142 In Scotland, the Quality and Standards process outlines the environment and drinking water standards the water authorities must meet and the investment that is required to meet them. This investment requirement is used by the Water Industry Commissioner to advise the Scottish Executive on customer charges (Scottish Executive, 2001a).

4.143 The recent (January 2001) consultation paper on Water Quality and Standards: 2002 to 2006 sets out the options available to the Scottish Executive and the water authorities on investment in water and sewage service infrastructure over the next few years. This notes that climate change may affect the investment programme by forcing a reassessment of priorities.

Sensitivity to climate change

4.144 The conclusion of the Scottish Executive-organised seminar, *The Water Industry – The Changing Climate*, was that climate change would have a substantial impact on the Water Authorities. The key issue is the changing precipitation patterns, particularly associated with more frequent flooding of property; sewer overflows operating more often because of high rainfall; and higher summer demand for water during prolonged dry periods.

Options for managing climate impacts

4.145 The Water Authorities own more assets in number and value than any other Scottish industry. Future planning and management of this infrastructure must take account of its long-life, up to 100 years, and the need to maximise its serviceability over the longest time horizon. Climate change is likely to generate new regulatory (compliance and financial) risk for the water industry.

4.146 The timescale on which the water industry must operate means that plans must account for the needs of future generations. It is unclear whether the infrastructure being

installed now has either the capacity or the flexibility to cope with the effects of climate and other change. It is clear that public acceptance of higher charges to pay for future investment will require a concerted explanation of policy by Government and environmental and financial regulators.

Potential Adaptation Strategies

4.147 The primary impact of climate change on the Water Service industry is the changing precipitation patterns. Recent flooding events suggest that the existing infrastructure is inadequate for meeting the demands of today's weather extremes, and is therefore unlikely to meet future needs. Reducing the likelihood of sewer flooding is the most pressing problem. Adapting existing infrastructure is not necessarily a matter of investing in bigger pipes, but also requires imaginative thinking about more sustainable urban land drainage, storm tanks, and upstream land use. Urban drainage control is already being updated in Part M of the Building Regulations.

4.148 The changing rainfall patterns may require a strategic reconsideration of Scottish water resources, particularly the water use and ecological impacts within river basin catchments and whether inter-regional transfers are required. The implementation of the Water Framework Directive may assist this process.

4.149 Raising customer awareness about environmental issues associated with rainfall, flooding and land use is an important element of managing climate impacts. Better emergency plans are needed for dealing with and understanding the needs of customers in the case of sewer flooding.

4.150 The requirements of the existing and forthcoming Directives on environmental protection and pollution will impact on the operation of water suppliers and this is likely to be exacerbated by the changing climate. Similarly, increasing competition in the water industry is likely to affect approaches to reducing water use, through licensing and more focus on management of water demand.

4.151 A climate change network in the water industry, comprising the Scottish Executive, the Water Authorities, SEPA and the WIC would provide a means of disseminating Scottish climate scenarios and identify the need for new climate data, such as short period rainfall data, along with benchmarking best practice.

4.152 There is a pressing need for the Water Authorities to integrate climate change into their business strategies, and investment programmes. All stakeholders in the water industry need to raise public awareness of the issues and acceptance of the costs of adapting to climate change.

Adaptation Priorities

4.153 As with the energy supply and transport sectors, the adaptation priority is to develop infrastructure robust to present weather extremes, by integrating climate risk into business planning and investment, and to develop a dialogue with stakeholders about the cost of such actions.

Health

4.154 Maintenance of public health is the responsibility of the 15 Health Boards in Scotland. The primary issue for public health in Scotland revolves around socio-economic pressures, such as diet, smoking, and communicable diseases (Kerr *et al.*, 1999).

Sensitivity to climate change

4.155 The UK Department of Health has studied the impact of climate change on health and this provides the most comprehensive assessment in the UK of the risks of climate change on public health. These suggest that:

- Far too little is known of the likely effects of climate change on health and a research programme should be put in hand;
- Winter deaths are likely to decline, perhaps by 20,000 per year; heat-related deaths are likely to increase in summer by perhaps 2,800 per year by 2050;
- Food poisoning cases linked to warm weather are likely to increase, perhaps by 10,000 cases per year from the present 100,000 cases, but these are largely preventable;
- Vector-borne diseases, like malaria, could become established in low-lying salt marshes in the UK but is unlikely to cause major problems. The more dangerous form of malaria is unlikely to become established because conditions will remain unsuitable. Tick-borne diseases such as encephalitis and Lyme diseases are not likely to increase significantly;
- Diseases associated with poor quality drinking water, like cholera and typhoid, are unlikely to become problems in the UK. Algal growths and blooms may become more prevalent and require close monitoring of water quality, but the impact is likely to be small;
- Increasingly severe storms will increase the risk of injury or death; flooding can lead to disruption of services and cause immense anguish;
- Deaths from air pollution is likely to decrease both as a result of Government policies and from climate change;
- Increased cataracts and incidence of skin cancer, by perhaps 30,000 cases by 2050, are likely in the UK, but are preventable.

Potential adaptation strategies

4.156 In Scotland, the primary negative impact of the climate arises from pervasive dampness and cold in dwellings. The key issue for reducing vulnerability is to improve the quality of housing against the damp and reduce the incidence of fuel poverty. The aims of any adaptation strategy are therefore aligned with those of the social policies of the Scottish Executive for reducing fuel poverty and improving the poor quality of housing.

Education

4.157 A fundamental component of any adaptation strategy is to improve the preparedness and awareness of society to forthcoming changes. In particular, managing climate risk requires awareness of both the opportunities and risks associated with the changing weather patterns. The results from the various socio-economic sectors suggest that the Scottish Executive plays a vitally important role as an educator, to improve awareness and disseminate information on climate risk, and as a facilitator, to encourage groups of stakeholders to integrate climate risk into their management strategies.

4.158 The Scottish Executive is undertaking a survey of public knowledge of and attitudes to the environment in the autumn of 2001. The questionnaire is likely to include questions on the causes of climate change, the implications, and opportunities for individual action driven by concern for climate change. This survey will go to 4000 respondents from the Scottish Household Survey (SHS), which will enable a link to be drawn with socio-economics.

4.159 A previous report, *Public Attitudes to the Environment in Scotland* (1991), found that the most important issues to the Scottish public in 1991 were pollution of rivers, lochs and seas and raw sewage put into the sea. Other environmental issues of major concern were the quality of drinking water, nuclear waste and damage to the ozone layer, followed by road traffic and fumes and smoke from factories. If people were asked to chose just one environmental issue/problem to improve no one issue was found to dominate.

4.160 The results of the forthcoming public survey will highlight the gaps in awareness that need to be addressed by a climate adaptation strategy. These are likely to include practical steps for property owners to protect their buildings from adverse climate impacts. The use of insurance policies is the most pervasive adaptation technique, but tends to transfer responsibility implicitly from the owner to the insurance company. It is in the public interest to educate property owners about possible climate impacts and opportunities for protecting their property.

AGRICULTURE, FORESTRY, FISHING AND BIODIVERSITY

4.161 The management of Scotland's natural environment resources is perhaps the sector most affected by climate impacts (Kerr *et al.*, 1999).

Fishing

Existing Policy Framework

4.162 The management of marine fisheries is driven by the European Common Fisheries Policy. The primary aim of the Common Fisheries Policy is to ensure rational and sustainable exploitation of fish stocks through conservation and management policies designed to protect resources and reflect the needs of the fishing industry.

4.163 Structural policies are aimed at improving the balance between catching capacity and available resources by addressing fishing effort. Conservation policies are aimed at regulating the quantities of fish caught, through a system of Total Allowable Catches (TACs) based on scientific advice. These TACs are allocated as quotas to Member States in accordance with

fixed keys based on historic fishing rights. They are complemented by a series of technical conservation measures intended to achieve more selective fishing, for example by setting rules on minimum landing sizes, minimum mesh sizes and gear design, as well as defining areas of seasonal closures, methods of fishing and target species. Opportunities to fish in third country waters are also secured through the Common Fisheries Policy.

4.164 The EU fisheries policy codifies existing behaviour such that where people have fished in the past they can continue to fish. Inevitably, this attempt to produce relative stability creates inertia in the industry and bars open access to the different fishing grounds. Nation states negotiate quota levels and implicitly become competitors.

4.165 The Scottish Executive attempts to ensure the continuation of the fishing industry in Scotland, as part of their rural development objectives. The UK Ministry of Agriculture, Fisheries and Food (MAFF) took the lead role in determining the UK position on the European Common Fisheries Policy. Respondents to this study suggested that the negotiating position of MAFF was perceived to protect English fisheries, such as sole, to the detriment of Scottish fisheries, such as haddock.

4.166 Parry (2000) argues that the chronic over-fishing of Europe's marine fisheries is a direct consequence of the failure of the Common Fisheries Policy to protect sustainable fisheries in the North Sea and the North-East Atlantic. The Common Fisheries Policy is undergoing a review, to be completed by the end of 2002. It has been suggested that this review will lead to more devolved management of fisheries within 6 miles of the coast and of various stocks not currently the focus of Common Fisheries Policy management. The Policy does not have an explicit climate change angle. However, respondents to this study suggested that the need for a proper ecosystem approach to sustainable fisheries management is increasingly accepted.

4.167 The framework for coastal fisheries is similar to that for offshore fisheries though there is inevitably more overlap with the onshore framework, such as management of pollution from land, the boundaries of the forthcoming Water Framework Directive, and the work of the various coastal forums around Scotland.

4.168 The management of freshwater fisheries in Scotland lies in the hands of a number of bodies ranging from central government to private individuals. The Scotland-wide, river-by-river salmon fishery district system for the management of salmon fisheries has existed for more than a century, although there are still a number of districts where salmon fishery boards have not been formed. In recent years, a number of Fishery Trusts have been established to provide salmon fishery boards with scientific advice. However, there is no equivalent structure for the management of other freshwater fish. There is a growing awareness of the need for a more holistic approach to management, encompassing not only all of the fish but also the freshwater environment in general (Scottish Executive/SNH, 2000).

4.169 The Scottish Executive are considering the framework of policies with which to protect and promote Scotland's freshwater fish and fisheries following a consultation exercise (Scottish Executive/SNH, 2000) designed to consider:

- measures to conserve freshwater fish stocks;
- present and potential threats to the fish;
- the current status of fisheries and how they are managed;

- scope for wider access to angling; and
- the prevention of introduction of non-native fish species to Scotland.

Also, in Summer 2001 the Executive will publish, for consultation, a Green Paper containing a number of recommendations for action over the short, medium and long-term future.

Sensitivity to Climate Impacts

4.170 Predicting the impacts of climate change on fisheries is complex. Fish are sensitive to many attributes of the physical and biological environment that may be influenced by the changing climate. The sensitivity to these attributes depends on the fish species and on the particular stage of their life cycle (Kerr *et al.*, 1999).

4.171 At a local fisheries level, Parry (2000) reports that short-term changes in the climate are likely to result in:

- Local changes in species composition and biodiversity;
- Local changes in population levels and in fisheries production.

4.172 Changes in migration patterns and species movements are easier to achieve in the marine environment than in small lakes and rivers so freshwater fisheries are, in general, more vulnerable to the changing climate.

4.173 Future impacts of climate on fisheries are uncertain because of the interdependence of factors such as over-fishing and other environmental pressures including the introduction of many non-native species and impacts of pollution.

Potential adaptation strategies in fishing

4.174 The aim of a generic adaptation strategy in this sub-sector is to enhance the flexibility of the managed resource, for example by changing activity or location, and to enhance the adaptability of unmanaged systems, by reducing non-climatic stresses.

A range of legislative mechanisms is in place at both European and Scottish levels to conserve marine and freshwater fish stocks and the habitats on which they depend. Declines in salmon and brown trout catches in Scotland in recent years and of marine species around Scotland, such as haddock and cod, highlight the difficulties in formulating policies that provide adequate protection for these species. A cod recovery operation is now in place.

4.175 Climate change is likely to worsen an already dire situation, because of the lack of flexibility both within the marine policy framework and by the users and consumers of the resources. Parry (2000) argues that adaptive management plans are required at several levels, including local, regional, national and EU, to address resource allocations and reduce the likely conflict between users of the resource. In the short-term, Parry (2000) suggests moving away from single-species stock assessment and allocations towards species groups or assemblages in order to increase flexibility. Economic incentives are required to change behaviour in an industry without the safety-net afforded to the agricultural industry. Education campaigns are required to help consumers understand the need for a more sustainable industry, through for example switching the fishing effort to new warm water fish and reducing our dependence on haddock and cod.

4.176 The Salmon Conservation (Scotland) Act was brought into force in April 2001 in an attempt to reduce exploitation of wild stocks of salmon following record low catches in 1999. The Act allows District Salmon Fisheries Boards to apply to Ministers for a much broader range of conservation measures in districts where there is no Board or where urgent action is required. The measures which are envisaged under the new Act will help to reduce local exploitation of stocks, in particular the most vulnerable components such as early running, multi sea winter salmon, and encourage sustainable management of fisheries.

4.177 The Water Framework Directive provides one opportunity to integrate the work undertaken by many different agencies and private owners and provide the strategic context in which to reduce the non-climatic stresses on Scotland's freshwater fisheries.

4.178 Respondents to this study indicated that the current funding mechanisms to improve rural development have not been effective in the development of Scotland's fisheries.

Adaptation Priorities

4.179 Climate change is one of many drivers of change in Scotland's fisheries, which require a move away from single species resource assessment towards a proper ecosystem approach to sustainable fisheries management, both offshore and in fresh waters. Use of the Water Framework Directive coupled to catchment ecosystem management, to underpin water quality and quantity, would benefit fresh water fisheries. This approach requires co-ordination between landowners and local and national Government bodies. Offshore fishing is reliant on the adoption of a more coherent ecosystem approach to fisheries management within the Common Fisheries Policy. A major component of any adaptation study is awareness raising of these issues with participants and consumers.

Agriculture

Existing policy framework

4.180 The Scottish Executive Rural Affairs Department administers a multifaceted series of schemes and grants to support agriculture in Scotland in accordance with the European system of support: the Common Agriculture Policy (CAP). Traditionally, the CAP worked through the control of prices for agricultural produce. High market prices are maintained and these guarantee minimum returns for producers of cereals, sugar beet, beef and dairy produce. Import and export controls serve to insulate the Community market from fluctuations in world prices, including those of pigs, eggs and poultry, though ongoing World Trade Organisation talks are likely to apply pressure on the EU to open up its markets to competition.

4.181 Sheep and beef cattle producers receive direct support at a fixed rate per animal within their quota. Dairy farms are levied if they produce more than a fixed quota of milk. In the arable sector, farmer's incomes are supplemented by payments per hectare of arable land. Larger farms must set aside part of their land to be eligible for payment and observe various management conditions. Other support mechanisms include structural assistance to improve farm structures and profitability, such as diversification into non-farming activities,

environmental inducements to minimise agricultural pollution and for conversion of agricultural land to woodland³.

4.182 The European programme, Agenda 2000, seeks to reform five areas of CAP: beef, milk and milk products, arable crops, rural development, and cross cutting schemes. The main thrust of the changes concern the reduction in support prices, which are compensated by increases in direct subsidies. The reforms are designed to improve the competitiveness of European agriculture; to produce more sustainable agriculture using less environmentally detrimental production methods; and to ensure vibrant rural areas.

4.183 Much of agriculture in Scotland faces a difficult task in view of the often harsh climatic and soil conditions, tied to remoteness from main markets. Respondents to this study argued that the support framework provided by the CAP is a vital component for the majority of producers to maintain income levels and thus maintain rural communities, which are to a large extent dependent on the multiplier effect of upstream and downstream jobs from agriculture. The multi-functional nature of Scottish farming is closer to norms in the rest of Europe than in England.

4.184 The Scottish Executive has published a Forward Strategy for Scottish Agriculture, which reviews the priorities and direction of Scottish Agriculture (Scottish Executive, 2001b). The establishment of a Scottish Parliament and Executive, with devolved responsibility in this area, was the catalyst for this work. More recently, the Foot and Mouth crisis has brought into focus the problems with the existing financing of agriculture. The headline issues from the Forward Strategy are:

- Scotland needs a successful, profitable farming industry;
- The food and drink industry is one of Scotland's natural strengths;
- Success depends on Scottish agriculture being amongst the best;
- Farming and crofting are part of rural development, not separate;
- High environmental standards in farming are vitally important;
- Future support to farming must be designed in a way which rewards the mix of benefits required by the Scottish public and does not mask market signals;
- Scotland will be one of the first countries in Europe to explore a new scheme of whole farm support, Land Management Contracts;
- Farming needs the right training, technology and advice.

The Strategy reports that the Scottish Executive will conduct a review of existing climate change research in Scotland to see if more is required. In addition, the industry will be involved in consideration of medium term options for reducing greenhouse gas emissions and in an analysis of flood risk maps to ascertain in more detail how farming is likely to be affected in future (Scottish Executive, 2001b).

4.185 Forthcoming changes also include schemes such as the Farm Business Development Scheme in lowland Scotland and the Agricultural Business Development Scheme in the Highlands and Islands. These schemes aim to provide innovative business development in order to assist in the restructuring, diversification or co-ordination of agricultural businesses and thereby increase income generation.

³ Information provided by the Scottish Executive Rural Affairs Department (SERAD) CAP Fact-sheet, Dec. 2000.

4.186 In addition to the changing support mechanisms from the CAP, agriculture is likely to be affected by developments arising from the UK Climate Change Programme. In Scotland, emissions from agriculture, forestry and land use accounted for around 37% of the total Scottish emissions of greenhouse gases. Following a revision of the methods of calculating land use emissions, this figure has been changed to around 20%. However, it is still an important sector for Scottish Executive policies to reduce greenhouse gas emissions. Scotland also has around 50% of the UK carbon sink capacity and changes of land use could have important implications for overall net emissions in the UK. Forthcoming measures are likely to focus on protecting soils high in organic matter and encouraging carbon sequestration in vegetation (Scottish Executive, 2000a).

Sensitivity to climate impacts

4.187 Parry (2000) argues that agriculture within Europe is particularly sensitive to climatic variability in the most northern and southern regions. In theory, warmer temperatures and higher atmospheric carbon dioxide concentrations will be beneficial to agriculture in northern Europe, though in Scotland increasing rainfall may limit or negate any benefits.

4.188 The former UK Ministry of Agriculture, Fisheries and Food (MAFF) has reviewed the impact of climate change on UK agriculture and suggests (MAFF, 2000):

- The range of crops will move northward;
- High quality horticultural crops are more susceptible to changing conditions than arable crops, particularly if water availability becomes a problem;
- The relative suitability of different types of livestock is unlikely to change significantly;
- The potential for soils to support agriculture will be strongly influenced by changes in soil water balance;
- Pests and diseases will change.

4.189 The report on potential UK adaptation strategies for climate change (ERM, 2000) argues that the key impacts are:

- Decreased water availability and quality as a result of higher summer temperatures and lower rainfall;
- Increased soil erosion and leaching as a result of higher winter rainfall;
- Problems of vehicular access in water-logged soils;
- Livestock stress as a result of warmer summers;
- Pest and disease outbreaks may become more common;
- Longer growing season and reduced frost days, leading to increased yields.

4.190 Kerr *et al.* (1999) argued that the key sensitivity of the agricultural system is to an increase in the variability of Scotland's climate, in addition to indirect factors such as the difficulty of access to waterlogged fields. The wet autumn of 2000 provided evidence of how climate impacts could affect business profitability.

Managing climate impacts

4.191 Parry (2000) discusses short- and long-term measures for adapting to climate impacts across Europe. Short-term measures include changes in agronomic practices, such as changes in crop varieties and date of planting and harvesting; changes in external inputs, such as fertilisers and pesticides; and practises to conserve moisture. The latter is likely to be less important in Scotland apart from some sheltered eastern areas. A number of these measures are likely to be undertaken incrementally by the farmer as a matter of course.

4.192 Long-term measures include changes in land use; development of more robust crop types; substitution of crops; modification of microclimate and irrigation; and changes in farming systems for a geographical locality.

4.193 Respondents to this study noted the benefits of the longer growing season with increased yields for grass and soft fruit in Scotland, but argued that farmers were struggling to see opportunities for themselves, not least because of the inherently variable Scottish climate. The extremes and variability of Scottish climate, such as intense rainfall, determined the capacity of Scottish farmers to adapt. Unfortunately, climate scientists are least confident about the forecast changes in extreme weather events.

4.194 An increase in rainfall is also likely to lead to an increased risk of infringing environmental pollution constraints. With the introduction of tighter environmental controls for point sources of pollution, diffuse agricultural pollution will become the biggest problem for water quality in the next few years. Respondents to this study noted that dealing with such problems means unpicking years of mistrust between farmers and environmentalists. There is a need to tease out the environmental agenda without engendering yet more hostility from the imposition of constraints on farm-level decisions.

Potential adaptation strategy for agriculture

4.195 Policies for adapting to climate change must provide a framework in which there is the flexibility for farmers to adapt their land use and farming systems whilst working with the practical implications of a changing climate.

4.196 At present in Scotland, waterlogged fields appear to provide one of the biggest business risks from climate change. MAFF (now DEFRA) are undertaking work to examine the implications of the recent wet autumn for agriculture. If we consider that adaptation to current climate extremes is generally consistent with adapting to future conditions, investing in machinery or developing and disseminating practices that minimise the adverse effects of waterlogging are likely to be beneficial.

4.197 The inherent variability of Scotland's climate means that events such as the timing of planting and harvesting are likely to change incrementally year by year. Forms of subsidy that encourage flexibility of farming systems or diversification of income provision, such as the Land Management Contracts mooted in the Forward Strategy for Agriculture, become powerful agents for increasing flexibility in response to climate change as well as socio-economic drivers.

4.198 Opportunities for Scottish agriculture inevitably depend on farm type and locality. With the increasing divergence in climate between Scotland and south-east England, it is clear that use of crop research from southern England will have less utility in future.

4.199 The UK Climate Change Programme details measures in England to encourage investment in energy crops, such as short rotation coppice and miscanthus. Short rotation willow coppice is currently the most suitable energy crop for UK conditions and can be grown productively on both arable and reasonable quality pasture-land. With a renewable energy target of 17-18% by 2010, Scotland would appear to be an ideal location for the development of energy crops. However, the development of associated biomass infrastructure is by no means certain at present.

4.200 Nevertheless the Climate Change Programme is likely to remain a driver of land use change in the UK and Scotland has particular opportunities for enhancing its carbon sequestration. One consequence of the drive for more flexibility in the agricultural sector, coupled to tighter environmental obligations, will be the blurring and perhaps in the longer-term the removal of the historic distinction between forestry, agricultural and nature conservation policy. Further development of the Farm Woodland Premium Scheme and associated encouragement to plant trees will be one facet of this trend.

Adaptation Priorities

4.201 The changing climate is but one of many drivers of change in the agricultural sector. The adaptation priority is to ensure that the ongoing changes in the structure of agriculture in Scotland build in the flexibility necessary to cope with the changing climate, particularly water-logging. In addition, to take advantage of economic opportunities associated with mitigating greenhouse gas emissions.

Forestry

Existing policy framework

4.202 The Forestry Commission is the Government Department responsible for forestry throughout Great Britain. Forestry is devolved, and Scottish Ministers direct the Commissioners' activities in Scotland. The Forestry Commission's National Office for Scotland serves as the Executive's forestry department. The Commission has a Board of Commissioners with duties and powers prescribed by statute. The Board consists of a Chair and up to ten other Forestry Commissioners, who are appointed by the Queen on the recommendation of Ministers. The UK Minister for Environment, Food, and Rural Affairs, after consultation with Scottish Ministers, the National Assembly for Wales and the Northern Ireland Assembly, represents the United Kingdom's forestry interests within the European Union and in the wider world, and also has responsibility for areas reserved to Westminster. Research, international affairs and plant health are amongst these issues. The Commission is responsible for advising Ministers and for implementing each country's separate and distinct forestry policy. It is funded separately in each country.

4.203 The Forestry Commission has two executive agencies: Forest Enterprise, which manages the forests and woodlands owned by the nation; and Forest Research, which delivers research to inform forestry policy. The Executive published last year a strategy for forestry

in Scotland, *Forests for Scotland: The Scottish Forestry Strategy*. This is the core forestry policy document and outlines 23 Priorities for Action under five Strategic Directions:

- to maximise the value to the Scottish economy of the wood resource becoming available for harvesting over the next 20 years;
- to create a diverse forest resource of high quality that will contribute to the economic needs of Scotland throughout the twenty-first century and beyond;
- to ensure that forestry in Scotland makes a positive contribution to the environment;
- to create opportunities for more people to enjoy trees, woods and forests in Scotland;
- to help communities use woods and forests to promote sustainable economic and social development.

4.204 Forests and woodlands owned by the nation account for almost 40% of Scotland's forests, an estate of 467, 000 hectares; the remainder of the forests are managed by a rich mix comprising other public bodies, traditional estates, institutional landowners, forestry companies, farmers and crofters.

Sensitivity to climate

4.205 Parry (2000) notes that most common tree species have a sufficiently large genetic variability to acclimatise to the forecast average changes in temperature and precipitation, but that changes in frequency of extreme events may cause problems. In northern Europe, Parry (2000) argues that increased precipitation and reduced soil frost will adversely affect forest operations and timber logging, while increased wind damage may affect harvesting procedures.

4.206 Respondents to the *Climate Change: Scottish Implications Scoping Study* suggested that the most serious risk to forestry in Scotland from climate change appears to be the possibility of more extensive wind storms, leading to more blow-down and limitation of tree height. Other negative impacts include increased pest and disease damage. Respondents argued that without better information on climate variability, it is difficult to quantify these impacts.

4.207 The Forestry Commission Information Note 31 provides advice on the implications of climate impacts for forestry and a more detailed bulletin is being prepared (Forestry Commission, 2000):

- Rising atmospheric carbon dioxide concentrations are likely lead to increasing tree growth rates;
- Warmer temperatures mean buds are likely to break earlier in the year, although the continuing presence of late frosts may increase frost damage, while a lack of winter chilling could cause problems in natural regeneration if seed fertility is reduced;
- Warmer winters are likely to affect the relationship between pests, pathogens and their hosts, with a possible increased incidence of disease;
- Higher mean wind speed and the expected increase in occurrence of storms may make woodland more vulnerable to wind damage;

- Wood quality could be affected by both the changing climate and the rising carbon dioxide concentrations, some detrimental, some beneficial. These include an increase in compression wood production in some species and higher wood densities.

Managing climate impacts

4.208 The Institute of Chartered Foresters (ICF) reports various issues that need to be considered by foresters when adapting to climate change (ICF, 2000). The uncertainties in future climate suggest that there is no definitive guidance on forestry practices. However, the ICF argue that the use of nature conservation policy based on specific sites should be counter-balanced by countryside-wide strategies that allow species and ecosystems to adapt to the changing climate on a variety of landscape scales.

4.209 Professional foresters already utilise site and climatic factors, such as wind-blow, in forest planning processes using Geographic Information Systems (GIS). The uncertainty over climate change suggests that continued diversification of species and age structures in forests, where opportunities allow, remain the best option. The changing climate is likely to influence some species choices, such as beech in southeast England, but this is less likely to affect Scotland. Since forestry is often practised on difficult sites, the ICF concluded that best practise policies could mitigate some of the impacts of the expected climate change, not least because many of the changes are expected to fall within the natural variation of climate in Scotland.

Potential adaptation strategies

4.210 A generic adaptation strategy involves increasing the flexibility of the managed system and improving the awareness of stakeholders. The ICF advises foresters and arborists to stay well informed of what is happening to the climate, and how this is likely to affect the biological and policy environment. In the light of this information, the ICF encourages foresters and arborists to:

- Consider changes in management practices in response to climate trends and impacts;
- Be aware of the likely impacts of climate change on woodland species and ecosystems;
- Engage with other interests in ensuring that trees and forests play a full role in the UK in mitigating the damaging impacts of climate change.

4.211 The UK Climate Change Programme makes clear the important role of forestry in protecting and enhancing carbon sinks, both through the Government's commitment to expand the forest estate in Scotland and through private initiatives and carbon offset schemes (DETR, 2000). Nevertheless, the current low timber price on the world market undermines the financial case for forestry expansion.

4.212 The development of an implicit cost of carbon dioxide equivalent emissions arising from Government policies to mitigate greenhouse gas emissions provides a driver for changing land use, the main influence on which has been CAP subsidies. Whilst the policy framework is unclear at present, land use policies will have to account for this change. The

Forestry Commission maintains a large estate in public ownership with the potential to adapt to the needs of carbon sequestration more quickly than in other areas of land use.

4.213 Changes in the subsidy structure for agricultural produce are likely to affect the management of the forest estate markedly over the next generation. A potential adaptation strategy needs to be built into this changing framework in which forestry is undertaken in Scotland.

Adaptation Priorities

4.214 Climate change is one of many drivers that are affecting forestry in Scotland. By their nature, forest rotations are managed over long time-scales so an awareness of the likely climate impacts is important. These are being built into the existing management systems. Perhaps most importantly, integrating forestry policy into a more sustainable land use policy is crucial for allowing the different ecosystems the flexibility to adapt to the changing climate. This includes taking economic opportunities associated with carbon sequestration.

Biodiversity

4.215 The impact of climate change on UK species and habitat conservation policy has been reviewed in detail by a DETR-funded study, *Climate Change and UK Nature Conservation* (Hossell *et al.*, 2000). This work has been summarised in the form of policy and research needs for Scotland by the Scottish Executive Ecological Advisor's Unit (Drewitt, 2000).

4.216 UK wildlife habitats and species are afforded protection through a range of legal and policy mechanisms. The global Convention on Biological Diversity sets the UK framework, which comprises the national UK Biodiversity Action Plan (BAP) strategy complemented by supranational and intergovernmental regional strategies. The EC 'Birds Directive' and 'Habitats Directive' are major contributors to implementing the EC biodiversity strategy.

4.217 Much of the emphasis of UK and European conservation policy is on protecting species and habitats that historically are declining. The existence of climate change poses fundamental questions about the endpoint of a biodiversity strategy, if the changing climate makes some habitat designations unsustainable. Hossell *et al.* (2000) argue that whilst many current policies are flexible in their interpretation, others such as the BAP objectives and key land use policies such as agri-environment schemes, need to consider climate change explicitly.

Sensitivity to climate change

4.218 Hossell *et al.* (2000) categorises habitats according to their vulnerability to climate changes, based on an amalgamation of factors such as the ability to translocate species and the significance for nature conservation. Scottish habitats deemed to be most vulnerable to climate change include:

- Montane habitats;
- Raised bogs;
- Soft coastal habitats.

Other habitats vulnerable to significant changes in species distributions and community composition are native pinewoods and mesotrophic lochs.

4.219 The report also details our knowledge of the response by species groups and habitat types to climate change, as well as identifying knowledge gaps. A considerable amount of information is available on the responses of birds, which in many cases are more closely associated with changes in agricultural practices and land use than climate change. The English Nature-led *Modelling the direct impacts of climate change on the nature conservation resources of Britain and Ireland* (MONARCH) study provides further information on the impact of sea level rise on wading birds. Similarly, extensive research on responses of plant species, particularly those of conservation interest, has been carried out.

4.220 Relatively little work has examined the effects on invertebrate populations or mammals of climate impacts though it is likely that socio-economic changes in the rural environment, such as fragmentation of habitats, will have a more important impact, particularly on mammals. Fish, amphibian and reptile responses are also poorly understood. Non-climatic stresses such as the introduction of fish species for angling may exacerbate any climate impacts (Drewitt, 2000).

Managing climate impacts

4.221 Respondents to this study noted that there is recognition that some species will gain and others diminish in response to the changing climate; there will be variation in species-specific response. Some species are spreading northward with a corresponding retreat of some northern species. The view that the current rigidity of European Directives and designations is inappropriate is gaining ground. Instead of a static site-based nature conservation system, which fossilises a fragmented landscape, more flexible approaches should consider how biodiversity objectives could be better integrated into other land use policies. This could involve a greater focus on functional ecosystems and more flexibility in defining boundaries between sites and the wider environment.

4.222 One major difficulty remains in deciding at what level nature conservation objectives should be defined: whether global, biogeographic, European, national or local, especially as climate change will affect biogeographic boundaries. A related concern is the need to avoid fossilising land management systems simply on conservation grounds. The ongoing review and development of agricultural policies in Scotland provides opportunities for more cross cutting approaches to biodiversity and land use.

4.223 Work has been suggested to begin determining which of the existing monitoring schemes could helpfully contribute to understanding the needs of climate-induced changes in biodiversity. The current monitoring in relation to climate variables is extremely fragmented in Scotland; the Environmental Change Network is one, but only has three sites in Scotland. The MONARCH project aims to investigate methods for dividing the UK and Ireland into similar climatic characteristics and to identify important conservation resources for each region. Other monitoring schemes are designed to measure changes to the national heritage resource, although are not linked to climate change, such as the Countryside Survey series.

4.224 An approach that is more integrated into the socio-economic changes occurring in rural areas would appear to be more sustainable than current conservation policy. Perhaps

most importantly, single species conservation efforts that ignore the wider context of climate change and social and economic evolution have a high risk of failure.

Potential adaptation strategies

4.225 Hossell *et al.* (2000) make five recommendations for information or policy as a means of adapting nature conservation policy and its approach to take account of climate change. These include:

- Further development of monitoring programmes;
- Explicit consideration of climate change in Biodiversity Action Plans;
- Readjustment of conservation policies and priorities to react flexibly to the changing geography of species and habitats;
- A more international view of habitat and species maintenance;
- More creative use of instruments such as agri-environment schemes.

4.226 As with the forestry and agriculture sector, an effective biodiversity strategy for adapting to climate change requires a co-ordinated approach to rural land use, which is singularly lacking at present. In particular, the priority for any biodiversity adaptation strategy is to operate within the changing framework of land use policies.

CHAPTER FIVE IMPLICATIONS AND RECOMMENDATIONS FOR SCOTTISH POLICY

5.1 The evidence from chapter four indicates the considerable extent to which the existing management or policy frameworks in the different socio-economic sectors in Scotland either implicitly or explicitly account for climate impacts. This fact perhaps should not be surprising given the notoriously changeable and often stormy Scottish weather. Nevertheless, it suggests that an adaptation strategy to climate change in Scotland does not require a fundamentally different framework to that already existing.

5.2 Two important implications from the results of this project are:

- There is a natural (and healthy) tension between the needs of strategic planning to cope with climate change and the local decisions needed to implement appropriate adaptation strategies to climate impacts;
- Many of the difficulties with respect to managing climate change reflect the crosscutting nature of its impacts. This can lead to a lack of clarity about or co-ordination between existing lines of responsibility.

5.3 The former point reinforces the need for a partnership approach between the Scottish Executive and stakeholders, including but not limited to local authorities, SEPA, land and property owners, insurers, water authorities, transport and energy supply companies. One good example of such a partnership is the Scottish Coastal Forum, which provides a national context for the work of local Coastal Fora that draw on representatives from the public and private sector with an interest or responsibility in local coastal issues.

5.4 The latter point reinforces the need for a strategic overview of activities in Scotland, both to enable the distribution of appropriate climate scenario information as it becomes available over the coming years and to encourage stakeholders to integrate such information into their management plans.

5.5 Adapting to climate change requires that the risks and opportunities associated with shifts in the weather be calculated, as with any external socio-economic or environmental change in conditions. In this sense, adapting to climate change is simply integrating climate risk management into the normal organisational planning process.

5.6 Managing climate risk requires awareness of the opportunities and risks associated with the changing weather patterns. The results of this study suggest that vitally important roles for the Scottish Executive are as educators, to improve awareness and disseminate information on climate risk, and as facilitators, to encourage groups of stakeholders to integrate climate risk into their management strategies.

BUILDINGS AND INFRASTRUCTURE

5.7 A generic adaptation strategy aims to develop infrastructure robust to future climate impacts. Buildings and infrastructure in Scotland are primarily sensitive to changes in precipitation patterns or intensities and to any increase in the frequency of intense storms. The climate scenarios are ambivalent about changes in storm frequency or intensity but

suggest that one of the defining changes in Scotland will be the changing precipitation patterns and intensities.

5.8 The management of vulnerable infrastructure across Scotland encompasses highly regulated utilities, such as the energy supply and transport industry, and the water authority. Nevertheless there are many similarities between them and the decisions they must take.

5.9 All have major capital assets with long lifetimes that are vulnerable to flooding or storm damage. The time scale on which these industries must operate means that plans must account for the needs of future generations. Climate change imposes a duty to think strategically about its effect on the value and management of assets and the life and time-scales of change for assets. This requires an understanding of whole life costs of assets. In the industries in which there has been under-investment for years, and assets are ageing, a balance must be struck between the public acceptance of higher charges to pay for future investment and risks from adverse climate impacts. This will require a concerted explanation of policy by Government and industry regulators. It is obviously in the interests of the industry, the regulator and the public to get the balance between investment and customer costs right over the long-term.

5.10 The present system of management in these industries puts a great onus on the quality of the regulatory decisions by the energy transport and water regulators. Some organisations in some of these industries have argued that the current regulatory system breeds inertia that impedes flexible adaptation to climate change (Scottish Executive, 2000c). Encouraging the integration of the management of climate risk into business plans must begin with the industry regulators.

5.11 The transport infrastructure and, to a lesser extent, the electricity supply infrastructure are unusual in that they often cut across the grain of the landscape, making them more vulnerable to flood risk or storm damage. The linear nature of the infrastructure has led to a narrow view of their impact on the surrounding landscape. More recently, the concept of zoning the landscape around these features provides an opportunity to minimise flood risks on the infrastructure and the adverse impacts from, for example, run-off. Examples include negotiations between Railtrack Scotland and farmers on adjacent land to plough parallel to the railway lines and plans for 'road corridors' along major road developments.

5.12 The onus is also on property owners to take steps to protect their buildings from adverse climate impacts. The use of insurance policies is the most pervasive adaptation technique, but tends to transfer responsibility implicitly from the owner to the insurance company. It is in the public interest to educate property owners about possible climate impacts and opportunities for protecting their property. It is also in the interest of local authorities to include insurers on their Flood Appraisal Group and listen to their advice, as suggested by NPPG7.

5.13 Local authorities have extensive estate that is vulnerable to climate impacts. Appropriate funding for monitoring and maintenance based on analysis of the climate risk will be required.

5.14 The key issue for all property owners concerns the land use planning system. When the correct framework is in place and implemented, then the vulnerability of properties is much reduced. In Scotland, the National Planning Policy Guidelines on Planning and

Flooding (NPPG7) provide a comprehensive framework to minimise the risk of flooding from future developments. Nevertheless, local authority planners are under intense and conflicting pressures to utilise land for development in particular localities and achieving an appropriate balance between flood risk and development has not always been successful. Further discussion between the Scottish Executive and local authorities on this matter may be appropriate.

FLOODING

5.15 According to the UKCIP98 climate scenarios for the next 100 years, Scotland is most sensitive to the increased flood risk associated with increased volumes of precipitation, particularly in autumn and winter, and more intense rainfall events. Certain coastal areas are also sensitive to the rising sea level.

5.16 Local authorities have powers to provide flood prevention measures. At present, river and coastal flood defences in Scotland are developed as a response to previous flood events. This is not an unreasonable approach. A more proactive approach to the development of flood defences, in other words a preventative strategy rather than a reactive strategy, will require substantially better data of flood risk across Scotland.

5.17 The development of flood defences has been low on the agenda for many local authorities in the past. As a result of this and the extensive development that has been undertaken in recent decades, the planned flood defences are simply keeping abreast of current flood hotspots that have arisen in part from previous planning decisions. These planned flood defences will be necessary to protect existing developments, but this situation implies a more strategic view of flood prevention is required across the landscape to minimise future flood risk.

5.18 A more strategic view of flood prevention ties in with the emphasis of sustainable development but makes more demands on stakeholder involvement, particularly upstream landowners. It requires a strategic view of the landscape, which for the case of flooding could be sensibly taken at a catchment level, and encourages imaginative flood attenuation solutions rather than 'end-of-pipe' engineering. SEPA's sustainable urban drainage (SUDS) provides one existing example of such thinking.

NATURAL RESOURCES

5.19 The management of Scotland's natural resources is the sector most sensitive to climate change. The forestry, agriculture and fisheries industries are also under intense financial pressure at present. The results from this project suggest that, above all else, adapting to climate change demands flexibility in the management of natural resources. Defining and attempting to conserve practices or one species in one location are almost certain to fail.

5.20 The offshore fishing industry is perhaps most vulnerable, not least because of the limitations of the current fisheries management regime. Clearly, adapting to climate change requires that appropriate ecosystem management is integrated into the ongoing revision of the Common Fisheries Policy.

5.21 Similarly, freshwater fishing has focused almost exclusively on salmon. Whilst salmon remain an icon for the pristine nature of Scotland's environment, adapting to climate change requires a more co-ordinated strategy for other fish species and the entire aquatic environment. The forthcoming Water Framework Directive provides one such vehicle for understanding catchment water dynamics, while the existing District Salmon Fishing Boards or equivalent organisations provide a voice for local stakeholders.

5.22 The impact of climate change on agriculture and forestry must be considered in conjunction with decisions about how best and to what extent to subsidise the development of rural areas. These are complex issues that require detailed consideration of regional rural policies, land use activities, soil type, prevailing climate and their likely changes.

5.23 The results from this study suggest that even to pose appropriate questions of the problem requires a more co-ordinated vision of land use than is currently the case. The fragmented and often overlapping nature of policies for forestry, agriculture and biodiversity impedes appropriate adaptation strategies. In the medium-term, drivers of change from mitigating greenhouse gas emissions, from sustainability issues and from biodiversity is likely to lead to a blurring and perhaps complete removal of the distinctions between policies for forestry, agriculture and biodiversity.

5.24 In the short-term, the results from this project suggest that continued local co-ordination within strategic landscape units is required to minimise adverse climate impacts. Existing examples of such co-ordination include management of diffuse pollution. Increasingly tight environmental controls on point sources of pollution is likely to lead to further concentration on diffuse pollution. The forecast changing patterns of precipitation are likely to increase the effects of diffuse pollution.

5.25 The use of strategic landscape units is common when managing natural resources and could be employed usefully in Scotland to explore appropriate policy frameworks for adapting the management of natural resources to climate change. At present, agencies such as the Forestry Commission, SNH and local authorities use different landscape-zonations depending on their function.

5.26 The use of landscape units would also determine the appropriate scale on which climate scenarios ideally should be based. Better resolution in climatic terms will not necessarily help with the framing of policies appropriate to larger landscape units, such as large catchments or extensive areas of characteristic soils such as the Flow Country. It may well be that for most purposes, climatic differentiation between a small number of units delimiting the west-east and north-south climatic divergence across the country and its altitudinal variation provides the necessary data for framing policies.

CROSS-CUTTING ISSUES

5.27 Work by the IPCC on adapting to climate change suggests that:

- Vulnerability to change is determined by the frequency and magnitude of extreme events and not on average events or changes in average events;
- Adaptations to current climate risks are generally consistent with adapting to future changed conditions, so we can usefully deploy them now;

- The capacity to adapt varies by region and through time;
- The enhancement of the capacity to adapt is necessary to reduce vulnerability.

5.28 Of these issues, work is in hand to improve information on likely climatic extremes in Scotland. Scotland's socio-economic sectors and its environment have developed under the prevailing variable climate, where storms and heavy rain are not uncommon. Much of the infrastructure was built to appropriate standards for the current climate risks. Infrastructure for which this is not the case, examples of which include some flood defences, reflect other changes in the environment, such as further urban development or under-investment over recent decades. Generally in such cases, upgrades are being undertaken now to bring the infrastructure in line with current climate risks. Scotland's capacity to adapt depends on effective integration of climate risk into management plans and awareness building of response options, particularly for flood and storm hazards.

5.29 Climatic extremes to which Scotland is most sensitive are increased precipitation, particularly intense rainfall events, and increased frequency of intense storms, though the UKCIP98 scenarios are ambivalent about the likelihood of the latter. A strategy to cope with an increased frequency of either of these climatic extremes must concentrate on the two key elements for adaptation, namely land use planning and appropriate management of long-life infrastructure.

5.30 The key issue in land use planning is to ensure a correct balance between a constraint on activities because of adverse climate risk and maintaining an acceptable level of development. This requires, firstly, avoiding an increase in flood risk where appropriate, and secondly, seeking to manage the threat of flooding only in cases where the need for development takes precedence over flood risk. The National Planning Policy Guidelines 7 (NPPG7) provides the appropriate framework within which local planners can take appropriate decisions.

5.31 The implementation of the Water Framework Directive provides an excellent opportunity to develop a strategic overview of catchment hydrology and so enable a more sustainable approach to flood prevention, along with meeting concerns about diffuse pollution and water abstraction.

5.32 The results of this study encourage the use of existing voluntary or statutory groups, such as the Flood Appraisal Groups with local authorities, District Salmon Fishery Boards, and Programme Assessment Committees for agricultural schemes, for disseminating information and enabling local decision-making.

5.33 Another example of stakeholder groups working together on cross cutting issues of interest is the Scottish Coastal Forum. This Forum coordinates the development of management plans by stakeholders for different areas of coastline. The benefits and limitations of their work are salutary to any attempt to develop this model of strategic oversight and local decision-making. Members of the Scottish Coastal Forum have noted generic issues that must be addressed for the system to work effectively. In particular, there is a need for strategic oversight from the Scottish Executive, which might be only the provision of timely climate data, but is also likely to require some funding.

5.34 The appropriate management of long-life infrastructure is generally the responsibility of private businesses or individuals. An adaptation strategy must work within the regulatory

structure, for businesses, or through education, for private individuals, to encourage appropriate planning and maintenance schedules.

PRIORITIES FOR THE FUTURE

5.35 The results from this study suggest that the priorities for a climate change adaptation strategy in Scotland should reflect the following:

- Climate risk management is integrated into the planning process of all organisations with responsibilities for long life assets. For example, for the water authorities, as a major holder of long-life assets, the adaptation priority is to develop infrastructure robust to present weather extremes, by integrating climate risk into business planning and investment;
- Mechanisms are in place to continually monitor and disseminate climate scenario information, as it becomes available;
- The delicate balance between minimising climate risk and enabling social and economic development through the land use planning framework is observed;
- Existing management frameworks in Scotland are utilised, but the development of local stakeholder groups are also critical for developing a strategy based on the joint strengths of strategic oversight by the Scottish Executive and local decision-making;
- The use of strategic management frameworks for defined landscape areas within Scotland would assist the development of adaptation policies for the Scottish environment;
- The development of measures to minimise greenhouse gas emissions from land use must be designed in conjunction with measures to minimise adverse climate impacts;
- Information on the land at risk of flooding is fundamental for an adaptation strategy in Scotland;
- The Scottish Executive play a vitally important role as educators, to improve awareness and disseminate information on climate risk, and as facilitators, to encourage groups of stakeholders to integrate climate risk into their management strategies.

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ANNEX 1

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