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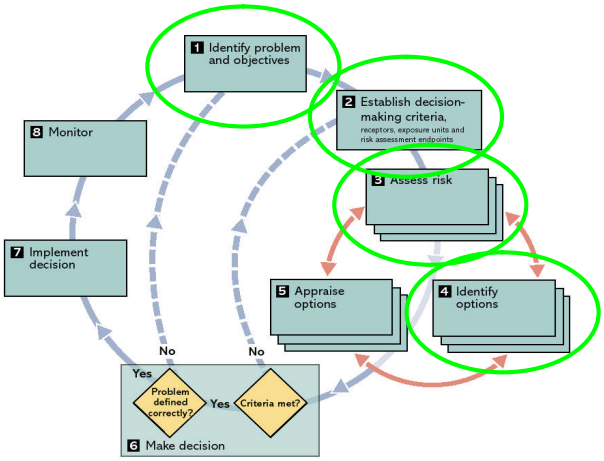
The Isle of Man Climate Change Scoping Study

Technical Paper 8

Sector impacts



Report for
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Our reference IoM001

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1. Introduction

This technical paper looks at the potential impacts and adaptation options for a number of key sectors reflecting the diversity of the Isle of Man's society, economy and environment.

The process follows the stages set out in the UKCIP Risk, uncertainty and decision making framework (see figure 1 below). Each sector has been laid out following the risk framework, allowing stakeholders to review, repeat or update the information presented at a later date.

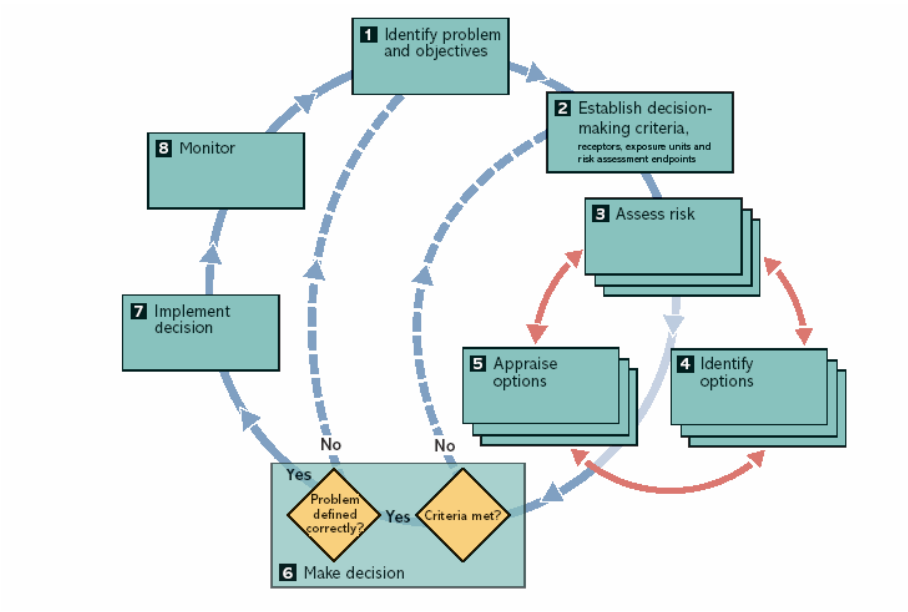

Figure 1: UKCIP Risk, uncertainty and decision making framework[1]

In this technical paper the key social. economic and environmental sectors for the Isle of Man have been categorised as:

- Transport
- Business and the economy
- Tourism
- Society and culture
- Historic environment
- Health
- Leisure and recreation
- Communications and energy infrastructure
- Water management
- Waste management
- Built environment
- Natural resources and environmental quality
- Marine environment
- Agriculture, fisheries and forestry

[1] Willows, R.I. and Connell, R.K. (Eds.). (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report. UKCIP, Oxford.

Stage 1 and 2: Baseline characterisation and decision making criteria

A baseline characterisation has been completed for each sector, reviewing the existing sector challenges, current and proposed strategies, programmes and action plans from published sources. This looks at all challenges taken from published sources, not just those which are driven by climate change or climate variability. Any current issues and problems are identified together with any receptors, exposure units and sensitivities (where information is available). The outputs presented here take into account the two workshops and discussions with stakeholders on the Island.

In these stages the following questions were asked:

- What are the important decisions for the Isle of Man both now and in the future?
- Is climate already an issue? Is it being taken into account now?
- Will climate change become a factor or more of a factor?
- Who are the key stakeholders?
- Are there any timescales involved?
- What are the criteria for recognising a successful outcome?
- What are the legislative requirements or constraints?

The responses are contained within a characterisation statement and a stages 1 and 2 issues matrix for each sector.

Stage 3: Impact assessment

A review of existing published sources and stakeholder engagement has allowed possible impacts to be identified. The active involvement of stakeholders has been particularly important during the process. The impacts have been provided in a series of impact matrices for each sector for ease of reference. Each impact has been classified according to information source.

This analysis is contained in a stage 3 impact matrix for each sector.

Stage 4: Identify Options

A number of potential adaptation options were identified ranging from the need to do something now or to monitor future change. The inputs from the workshops and the steering group played a major role in this stage, which were combined with existing published impact assessments in order to provide a wide range of potential responses.

Stage 4 adaptation option matrixes have been included for each sector and have been arranged following the process developed for UKCIP as part of the UK Adaptation Policy Framework. This identifies adaptation actions under two broad headings: building adaptive capacity (BAC) and delivering adaptive action (DAA). A comprehensive

description of the actions for BAC and DAA can be found in technical paper 12. Examples of actions for BAC and DAA are:

Building Adaptive Capacity

Examples include:

- Research / data collection and monitoring e.g. use research to better understand the climate risk
- Changing standards, regulation, policy e.g. strengthen planning guidance on developments in flood risk areas;
- Awareness raising /working in partnership e.g. increase public awareness about coping with flooding at home.

Delivering Adaptation Action

Examples include:

- Prevent the effects: structural and technological e.g. strengthen building foundations to cope with climate change
- Accept impacts and bear loss e.g. accept that some land will flood in winter
- Spread/share impacts e.g. insure business against weather losses
- Avoid negative impact / exploit opportunities e.g. grow new agricultural crops better suited to new climate

Where possible 'Low Regret', 'No Regret' and 'Win-Win' options were identified. These are classified as follows:

- *No regret* options are those that will deliver benefits whatever the extent of climate change (and even under the absence of manmade climate change.) A no regret option is determined to be worthwhile now (in that it would yield immediate economic and environmental benefits which exceed the cost), and continue to be worthwhile irrespective of the future climate.

- *Low regret* options are where the implementation costs are low (bearing in mind the uncertainties with future climate change projections) whilst the benefits under future climate change may potentially be large. For example, raising awareness of flood risks and the need to use water wisely are all low regret options.

- *Win-Win* options are where the options deliver a benefit for adapting to climate change and also a benefit for another purpose. For example, improving food hygiene and preparation standards meets the challenge of increased risks arising from higher temperatures but also improves overall hotel and catering standards for the benefit of tourism on the Island.

acclimatise commentary

At the end of each sector a commentary has been provided by acclimatise which summarises the key risks and opportunities. A discussion as to other important aspects is also included, together with any significant adaptation options that should be investigated.

2. Transport

Characterisation

The Department of Transport is responsible for the provision of infrastructure for travel, transport and navigation of internal and external traffic for the Island. It covers highways, harbours, the airport and air services. The Department of Tourism and Leisure is responsible for the operation and maintenance of the Island's bus service, the Isle of Man Steam Railway, the Manx Electric Railway and the Snaefell Mountain Railway.

The main airport is Ronaldsway Airport near Castletown. Seven flight operators enter the island from UK, Scotland and Ireland. The airport handles over 700,000 passengers a year, serves 14 destinations, airfreight and mail.

There are approximately 500 miles of roads on the island. There is an island wide network of scheduled bus services. These link together the main towns and operate daily throughout the year.

The Steam Railway gives access from Douglas to the south of Island during the summer months (Easter to October). The Manx Electric Railway runs north to Laxey and Ramsey. The Snaefell Mountain Railway climbs from Laxey to the Island's highest peak. These services are also seasonal, running from Easter to October.

The Steam Packet Company provides passenger and freight operations to and from the Island. Passenger and car ferries operate to Heysham, and there is a fast service that runs in the summer months to Liverpool, Dublin and Belfast.

There are three deep-water anchorages in the east, west and south of the Island. There is a quayside mooring at Douglas for vessels up to 120m. Port St. Mary and Port Erin are fishing ports with a strong leisure yachting presence. Douglas is the only Manx port with dedicated passenger handling facilities and with roll-on, roll off vehicle services. The port provides specialist berths for oil and gas tankers as well as general cargo vessels, fishing vessels and the occasional survey, customs and naval vessels.

Stage 1 and 2: Transport

Defining the issue
Transport
Response

Transport is a critical sector due to the Island's location. Air and sea links are essential for individuals, businesses, movement of goods and materials, energy, tourism and the economy. The road, rail and bus infrastructure plays a crucial role in maintaining a high standard of living and the Isle of Man's 'quality of life' reputation.

Issues

The Department of Transport business plan includes major improvements and investment for the transport sector. Particular actions include the development of marina activities and aims to increase travel opportunities. Transport plays a huge role in assisting the economic development (including tourism) of the island by supporting the required infrastructure facilities.

An integrated transport strategy is currently being determined for the island. Issues highlighted include:

- sourcing and obtaining suitable steam coal for the Isle of Man Steam Railway
- deteriorating infrastructure and an increasing challenge to maintain the Island's roads (25 % of the Island's roads have a residual life of <5 years and 90% of the roads require attention).
- improving air and sea transport, and in particular increasing capacity, with new services and lower fares (the airport forecasts a doubling of aviation movements)
- flooding of highways together with the risk of storm surge and tidal flooding resulting in significant asset and property damage, disruption and risk to life

Climate related influences include tidal conditions and changes to ports e.g. the introduction of breakwaters affects access for ships.

Future strategy and programmes include a major refurbishment of the Douglas Promenade due for 2009. A proposal to extend the main runway has been submitted for planning permission. Harbour development plans for Douglas outer harbour and a marina in Port St. Mary are also detailed within the Island's strategy. There is a planned programme of rail infrastructure renewal together with the development of a long-term maintenance strategy for highways.

A reliable and efficient transport system is a primary determinant of both quality of life and economic success. The workshops identified the impact of winter storms and failure of infrastructure as key issues for the Island in a changing climate.

For the purposes of this report the stakeholders at the workshops identified the problem (stage 1 of the UKCIP RUD framework process) as:

How can the Isle of Man manage, maintain and develop the highways, airport, harbours, rail and bus services in order to provide a safe, reliable and high quality service to visitors and residents in the face of climate change?

The following needs to be considered when undertaking this analysis:

- Robustness of any developments
- Asset life
- Integration of transport
- Use of transport by business
- Cross sector impacts
- Flooding

For transport as a whole, adaptation to climate change is not the main driver. However if climate risks are not considered then problems and issues may be exacerbated. This has already been seen in extreme events that have occurred on the island, for example the windstorm event of Jan 2006 and the tidal flooding event in 2002.

Stakeholders include: transport users, wider public, transport operators (Department of Tourism and Leisure, Department of Transport), businesses, MHKs, Steam Packet Company, boat owners, airlines

The Government's current objectives will determine the success criteria for a safe, reliable and quality transport system. Specific objectives are:

- To maintain and develop the Island's ports to ensure that they are able to meet the needs of the traveling public and air and sea carriers (from Island Government Business Plan 2005 – 2008)
- To construct and maintain an appropriate highways infrastructure

The Government's indicators / measurements for these objectives are:

- Satisfaction rates with service levels and landside facilities in air and sea passenger surveys
- Effective lifespan of the Highway Infrastructure

<u>Current activities</u>

Current activities on the Island which address climate variability include:

- An integrated transport group, although it is not clear if their remit extends to considering climate impacts and adaptation
- Terminal extensions at the airport
- Coastal erosion and protection works to protect roads e.g. at Gansey beach

- All Island Strategic plan addresses transport issues – this covers a range of sectors and includes references to climate change adaptation and mitigation actions.
- Tidal flooding research is going on to provide better warning systems.
- Sand bags are provided when flooding is expected
- The rail infrastructure renewal program has meant that track, ballast and drainage have been improved in respect of the Steam Railway, and work is ongoing in respect of the Manx Electric Railway and Snaefell Mountain Railway.

Stage 3: Transport impact matrix

Transport	Potential risks and opportunities		
	Air / Sea	**Public transport / Infrastructure**	**Private transport**
Increasing summer temperatures (H)	• Load factors on aeroplanes (A) • Runway length (A) • Increasing risk of fog (A) • Air strike – if more insects on grass areas – encourages birds onto runway (A) • Increased leisure activity – safety concerns for boat owners and other users e.g. swimmers (A) • Increase in 'water' tourists and water sports (A) • Increase in demand for transport to the Island	• Greater use of rail (A) • Less use of transport as people opt to walk (A) • Increasing visitor numbers from tourists may increase road congestion with limited ability to increase rail capacity to compensate (S)[2] • Track failure (A), impact on rails and points, increased risk of buckling rails (S) [2] • Modes of transport could shift e.g. more walking and cycling (S) [3] • Increasing risk of accidents (A)	• Increased use (A) • Increase in motorcycle use (A) • Road safety concerns (A) • Increased pollution from increased road traffic (leading to increased incidence of asthma and other respiratory problems and so devaluing quality of life – one of the Island's greatest assets) (S) [2]
Increasing winter temperatures (H)	• Increasing use for tourism (A) • Reduce need for de-icing at the airport (A) • Maintenance issues for car parking at the airport – extensive planting is becoming an issue (O) • Roads will require less road salt (S)[4] • Less risk of fog (A) • More water based travel (A)	▪ Extended leaf-fall season (drain blockage, slippery roads) (A)[5]	• Safer – reduced frost risk (A) • Less winter highway maintenance (A)
More extreme high temperatures (H)	• Load factors of airplanes taking off - increasing temperatures affect weight take off amounts (A)	• Engineering issues with increased rail activity (A) • Decrease usage of public transport (A) • Premature asset failure (A)	• Increase usage as private transport more comfortable / has air conditioning (A) • Subsidence to roads increase (S) [2]

[2] Southwest Scoping study. Metcalf, G., Chambers, F., Charlesworth, A., Forrest, V., Hunt, J., McEwen L., Russell, K., and Schofield, S. (Eds), Warming to the Idea, Technical Report, South West Region Climate Change Impacts Scoping Study, 2003, Cheltenham, UK

[3] London's Warming: A Climate Change Impacts in London Evaluation Study. London Climate Change Partnership November 2002

[4] East Midlands Sustainable Development Round Table. The potential impacts of climate change in the East Midlands. Entec UK limited August 2000

[5] UK's Department of Transport Workshop on Assessing the Impacts of climate change on the road network.

[6] Prioritising future construction research and adapting to climate change infrastructure (transport and utilities) By M I Wilson and M H Burtwell PR/IS/13/02 CRISP Commission 01/13 Feb 2002 TRL

	• Premature asset failure (A)	• Road surface deformation (A) • Failure of bridge expansion joints (A) • Failure of vehicles and components (A) • Increased driver fatigue (A) • Decreased ability to perform maintenance activities (e.g. surface dressing) (A) • Increase in the maximum service temperature will increase the incidence of rutting on an asphalt pavement, whilst a decrease in the minimum service temperature will increase the likelihood of cracking.[6] • Increase in the incidence of fretting of road surfaces, which in turn will increase maintenance expenditure[10]	• Increase in cyclists may lead to increase in accidents, like the warmer, drier summer of 1995 where it was noted that cycle and motorcycle accidents had increased (Thornes 1997) (O). [7]
Less extreme low temperatures (H) (Lower growing season and reduced frosts)	• Less de-icing of planes and therefore less pollution and cost savings (A)	• Less frost damage to roads from winter cold, so potentially less frequent need for road repairs (S) [2] • Encroachment of vegetation obscuring road signs, requiring more frequent maintenance and therefore increased costs (S) [2] • Increased weed growth on rail tracks requiring extra maintenance (S) [2]	• Fewer ice / snow related road traffic accidents (S) [2]
Higher winter rainfall (H)	• Increased erosion of assets (A) • Drainage overload / flooding (A / O). Observed in flooding event at airport. • Failure of drainage systems? (already happened in tidal surge event). (O)	• Increase in public transport usage due to decrease in walking (A) • Flooding (A) • Increased erosion of assets (A) • Increase landslip occurrence (A) • Drainage overload (A) • Provide better bus shelters and rail platform canopies (S) [2] • A small increase in storm rainfall could require the significant modification of drainage systems to maintain current service levels.[8]	• Flood risks to roads (A) • Increase in usage (A)
Less summer rainfall (M)	▪ More dust on runway	• More detritus on roads, slippery surfaces (A) • Less dilution for road run-off (pollution) (A) • Need for more gully cleaning (A)	

[7] Thornes J E (1997) "Transport" in Economic Impacts of the Hot Summer and Unusually Warm Year of 1995, University of East Anglia 129-138. Referred to within East Midlands Scoping Study
[8] UKWIR. 2004. Climate Change and the Hydraulic Design of Sewerage Systems (Executive Summary). Report 03/CL/10/2. UK Water Industry Research, London

More intense downpours (H)	• Flooding (A) • Disruption to air services (A)	• Flooding (A) • Increases risk of flooding of railway lines, landslips and bridge failures (S)	• Increased risk of flooding (R) • Increase in road traffic accidents (A) • More surface water overload on roads (S) [2]
Sea level rise and increased coastal flood risk (H)	• Runway extension may impact on sea environment, habitats – effect of sea level rise and changes to erosion patterns (A) • Tidal flooding is a major issue – an increase in storm surge and sea level rise may contribute to increase tidal flooding. (A) • Stability of structures (A)	• Flooding (A) • Failure of coastal defences (A) • Service disruption	• Inundation and damage to coastal roads (O).
Possibly more winter storms (L)	• Service disruption (A / O) • Damage to infrastructure and vessels (A / O)	• Damage to infrastructure (A / O) • More trees falling on to road and rail network, so higher budget and more operatives required to maintain and clear network (S) [2] • Damage to overhead wires (A) • Increased risk from stones/sand thrown ashore	• Service disruption (A / O) • Increased risk from stones/sand thrown ashore

Key
A = Accepted wisdom / Anecdotal evidence
O = Observed, the impact has already been seen
S = Information obtained from other scoping studies / source providence unclear
R = Research work has been undertaken that demonstrates this impact

Confidence levels (based on the UKCIP02 scenarios[9])

H = High M= Medium L = Low

[9] Hulme,M., Jenkins,G.J., Lu,X., Turnpenny,J.R.,Mitchell,T.D., Jones,R.G., Lowe,J., Murphy,J.M.,Hassell,D., Boorman,P., McDonald,R. and Hill,S.(2002) Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

Stage 4: Adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Higher taxation on 'gas guzzling' vehicles. Tax on CO2 output, more tax on multiple cars per household • Implement integrated transport document • Control surface run-off from land adjacent to highway • Speed management	• Minimise car use by relocation of some government offices and encourage electronic conferencing • Relocation of business to other towns • Consider charging road users for travel on vulnerable roads	• Put freight on to railways. Recreate integrated rail system – providing an alternative to the road
	Research / Data collection / Monitoring	• Survey the coast. Identify strategic locations that cold be vulnerable to damage due to age, conditions etc (no regret) • Cost benefit analysis of houses in flood plains and of measures needed to mitigate damage (no regret) • Improve flood alerts, storm warnings • Avoid development on floodplains • Stability of earthworks • Effect of temperature on assets • Gain flood risk data for individual rivers and understand flood plains • Early warning system for severe weather?	• Farmers grow crops for bio fuels • Research into electric cars and other fuels • Use of railways as commuter transport brings in other options for moving people in the event of loss of roads in storm events • Move coastal roads inland • Minibus circular routes to help tourism and holiday makers in scenic areas (as tourism increases) • Identify which roads are susceptible to flooding	• Integrated transport policy – realistic but not idealistic • Need to improve public transport in general • Resilience of road surface materials to heat • Road / tyre design for grip in varying conditions
	Educational / Behavioural change / Awareness raising / working in partnership	• Better public transport, commuter trains from Port Erin to Douglas. More effective links for main bus routes. • Education for children on future environment (Low regret) • Greater use of public transport / car sharing • Dangers to road users of travelling in high temperatures / storm events	• Less reliance on 'One person, one car' syndrome.	

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Ensure strategic spares in stock for linkspan and other critical equipment to minimise disruption	• Adapt roads to provide coastal defence	• Insure Infrastructure
	Accept impacts and bear Loss	• Agree roads that can be allowed to be lost or are too vulnerable to be maintained	• Consider moving Manx electric railway further inland to avoid risk of coastal erosion • Close roads at risk	
	Prevent effects: structural / technological	• Improve land / storm drainage to prevent flooding / damage to roads • Ensure EIA on runway extension takes impacts of climate change into account (no regret) • Where financially viable enhance river banks to contain flood water (low regret) • Improve earthworks design • Asset vulnerability inspections and mapping • Strategy to retrofit assets to cope with climate change • The use of low maintenance vegetation to act as buffer zones, whilst not hindering the growth of other vegetation.	• Provide more suitable vessels better adapted to cope with expected increased in winter storms (e.g. larger Seacat) • New road schemes to have improved drainage systems e.g. Peel Road • Upgrading of railways to use for commuters • Provide better harbour facilities with more sheltered berths and approaches to take into account more inclement weather events	• Review previous flood events and reinforce road / drainage infrastructure to cope. • Potential to upgrade railway link from Ramsey to Port Erin to modern fast, comfortable and low floor recess metro system. And also include freight capability. • Stabilise existing earthworks
	Avoid / exploit changes in risk	• Encourage use of electric cars and more fuel efficient ones • Use TT course as testing ground for solar power and other non-fossil fuel vehicles (win win) • Provide better bus shelters and rail platform canopies (S) [2] • Alter winter maintenance to include climate change • Develop flood disaster emergency management plans	• Aircrafts – instrument landing systems – use technology so planes can land in cloud. • Prepare plans and equipment to tackle storm events more effectively	

acclimatise commentary

Transportation links to the island are already at risk from extreme events (e.g. major storms and river, coastal and storm surge flooding); climate change will increase the risk of disruption. Design, maintenance and operational standards will need to take climate change into account if the Island is to meet its objectives for a safe, reliable and quality transport system.

The management of, and response to these types of events should be given further consideration.

There are a number of major transport infrastructure projects planned for the Island (i.e. marina and harbour improvements, Douglas promenade, the airport and the rail infrastructure renewal programme) where the design life will extend into the middle / latter part of this century. It is recommended that the potential climate impacts on the design, operation and management of these facilities must be taken into account.

Using historic climate data as a basis for design will reduce the resilience of assets to cope with future climate change, leading to a risk of infrastructure and service failure. Climate proofing new projects during the design stage through an integrated risk assessment process may lead to significant cost savings, when compared with the costs of extreme events and future remedial works. The work undertaken in technical papers 5 and 7 exploring the costs of extreme events illustrates the impact of climate change on transport infrastructure and services.

Maintenance procedures for existing infrastructure will need to be regular reviewed to ensure that disruption is minimised, service maintained and the effective use of resources, including finance, is assessed. For example, an increase in the incidence of fretting of road surfaces will in turn increase maintenance expenditure.[10] Furthermore, hotter drier weather will increase the risks to break-up of asphalt surfacing. Both of these raise important issues of safety and maintenance, particularly for motorcyclists, especially as the TT races play a vital role in the tourism of the Island.

The current transport demand forecasts may be less robust due to the effect of climate change. Indirect impacts and adaptation responses taken by other sectors need to be taken into account e.g. tourism and the built environment.

Examples of potential impacts

- Disruption to transport modes from flooding and other extreme weather events.
- Maintenance and repair of existing assets need to take into account climate risks.
- Asset failures under increasing temperatures e.g. road surfaces, expansion joints, railway track and equipment.
- Impact of storm surge and tidal flooding on coastal roads.
- Increase in cycling and motorcycling accidents in summer.

[10] Prioritising future construction research and adapting to climate change infrastructure (transport and utilities) By M I Wilson and M H Burtwell PR/IS/13/02 CRISP Commission 01/13 Feb 2002 TRL that refers to unpublished project report by UK's Transport Research Limited (TRL) on climate change and the Highways Agency. 2001

Examples of opportunities

- Climate proofing new projects at the design stage may lead to significant longer term operational and capital cost savings.
- Reduction in de-icing of runways and aeroplanes, with consequential cost savings and improvements in surface water discharge quality.

Potential adaptation options

- Improve land / storm drainage to prevent flooding / damage to roads
- Strategy to retrofit assets to cope with climate change
- Asset vulnerability inspections and mapping
- New road schemes with improved drainage systems
- Maintenance procedures and standards regularly reviewed to take the changing climate into account

3. Business and the economy

This section provides an overview of business activities and the Isle of Man's economy. Business issues, impacts and adaptation options are also to be found in some of the other sectors contained in this report, e.g. Communications and Energy, Tourism, and Transport etc..

Further consideration of the impacts of climate change on the Isle of Man's economy is provided in technical paper 9 (The Isle of Man's economy in a global context).

Characterisation

The economy is currently experiencing a phase of growth slower than that achieved in the late 1990's. The slowing down is consistent with the global trend. The anticipated economic outlook for 2004 onwards is that of recovery, with growth rates in real terms increasing from around 5% in 2003/04 to 6.5% in 2006/07. Commensurate with the slower rate of economic expansion, it is anticipated that the resident population over the next three years will grow at rates of around 0.6% - 0.7% per annum.

The Manx economy in 2003/4 experienced GDP growth of 9.1%, with real growth being 6.3%. Within a sector breakdown of the national income it demonstrates that:

- The insurance, finance and business services and information and communication technology sectors are important; contributing 35.6% of Manx sourced income.
- The economy grew strongly as a whole in 2003/4, with only clothing and footwear showing negative growth.
- Utilities experienced strong growth of 40.5%.

Baseline data on national income dating back to 1993/4 are available in the *Digest of Economic and Social Statistics*. A comparison between 1993/4 and 2003/4 shows that the contribution of the financial sector has increased over the period slightly, and that manufacturing has significantly declined. This may be important when evaluating socio-economic trends in analysis of climate change impact scenarios. It is interesting to note that the tourist industry's share of income has fallen over the period.

Employment within the Island is good, with the financial sector being important. Insurance, banking and other financial institutions make up 17.5% of Manx employment, which is lower than its share of income. The Island's changing economic structure has led to an overall reduction in unemployment beginning in the latter half of the 1980s and has served to remove most of the seasonal element from the figures. Current unemployment at some 2.0% of the economically active population is well below the United Kingdom's national average. To create further capacity for economic growth the Government continues to consider measures, which will increase the size and productivity of the workforce from amongst the existing population.

Although unemployment remains relatively low the trend recently has been upward. Increasing unemployment has a significant impact by reducing revenue by the loss of national insurance contributions whilst increasing expenditure by way of administration and benefit payments. If the trend continues it is likely that additional resources would need to be found to meet demand.

Manx income per capita relative to the UK average has risen dramatically since 1994/5. Manx income per capita is now £17,309 compared to a UK national average of £16,391.

The average house price on the Island has risen from £84,657 in 1995 to £216,542 in 2004. Manx properties are considerably more expensive than houses in the UK as a whole. To provide a comparison, the average UK house price in 2003 was £155,485. This will significantly impact on values of property loss due to subsidence and increased flooding, both of which may result from climate change. The Manx housing stock has almost doubled since 1961.

Retail is the single biggest employment sector on the Island and contributes significantly to the high quality of life enjoyed by residents, the tourism and other business sectors. As well as servicing customer's needs directly, retailers distribute and market a wide range of locally produced products from the agriculture and manufacturing sectors on the Island, reinforcing a total quality approach from raw material to consumption. A large variety of (particularly local) retailers service the tourism sector in terms of restaurants, café's, bars and gift & craft shops. With shopping becoming a huge leisure activity in modern life, well-run retail businesses also capitalise on the discretionary expenditure of visitors to the island.

The town centres around the Island are predominantly Manx owned retail businesses. The main shopping towns are Douglas, Castletown, Port Erin, Peel and Ramsey. The major retail sector, food, includes the supermarkets: Shoprite, with 7 stores around the island, Safeway in Douglas and Ramsey, Tesco in Douglas, Marks & Spencer Food in Douglas, Pickwicks with their Spar offer, the Manx Co-op and numerous locally run "convenience" stores. This sector also includes butchers, bakers, cafes, pubs, off licences, newsagents and post offices etc. A wide variety of cafes and restaurants serve the needs of residents and visitors. These include country inns and tearooms as well as town centre restaurants and fast food outlets. [11]

DIY, home improvements, home furnishing, toy & hobby, household electrical goods and gardening are well represented. There are numerous hairdressers and beauty salons, plus opticians, chemists and gyms. In keeping with the relative affluence of the population, gift shops, antiques shops and jewellers flourish on the Island and at the other end of the retail spectrum Charity shops benefit from the recycling of clothes and possessions.

All the top car manufacturers are represented on the island and this is backed up by a thriving garage and petrol forecourt sector. The Isle of Man, considering the size of its population, has a diverse cross section of fashion retailers, from budget high street brands to some of Europe's top designers, and excellent locally owned fashion stores with unique designs and high quality service.[11]

[11] Manx business website www.mbc.org.im

Stage 1 and 2: Business and the economy

Defining the issue
Business
Response

The Isle of Man Government's *Economic Strategy 2004* highlights the potential of the economy to grow in the future, with positive linkages to increase:

- growth in personal disposable incomes and wealth worldwide;
- the emergence of new global markets (particularly Asia);
- ongoing global moves towards economic integration and the removal of capital and currency controls;
- bilateral and multilateral measures to reduce protectionist measures;
- ongoing cross-boundary movement of labour; and
- ongoing technical advances.

The relationship with the EU market is noted as potentially limited by restricted terms of access under Protocol 3 of the UK's Act of Accession. There are also concerns regarding demographic ratios of the working population vis-à-vis those in retirement. It has been suggested that a strategy needs to be established aimed at encouraging more people to better provide for their retirement, in order that they may enjoy a more comfortable retirement and that the financial burden on the state as the forthcoming demographic changes take place does not have a negative effect.

The Island's economy is changing, as the past successes cannot be taken for granted in the future. The world economy is becoming ever more open. Low-cost economies are competing aggressively for business and jobs. The strength of sterling remains an issue for exporters. The impact of new technologies is becoming increasingly profound. Economic performance in the major industrialised nations is mixed, trading conditions remain difficult and the future uncertain.

Diversification, within the context of sustainable economic progress remains the key to future prosperity. Over 20 years ago the government embarked on an ambitious strategy to establish the Island as an international centre for financial services. The Island is now well established as an international centre for financial services and over more recent years the government has supported a number of new developments, for example in shipping, film and media production, e-Business, as a means of diversifying the economy to make it more resilient and to achieve growth in real terms. However due to this high level dependency on the finance industry it is thought that this also makes the Island vulnerable to change in this sector.

The government is actively pursuing further opportunities for diversification and, in particular, in relation to the space industry, civil aviation, e-Gaming, high-technology manufacturing and service provision based on innovative intellectual property, corporate headquarters and distribution businesses. The government considers that it is only through a proactive diversification strategy that the Island can continue to achieve sustainable growth in National Income, improvements in the quality and range of jobs available, and government revenues to the funding of high quality of public services.

The government has the following objectives with regard to e-business:

- To develop and implement E-business strategies that support economic development across all key sectors.
- To co-ordinate E-business initiatives across Government and between Government and the private sector.
- To raise the profile of the Island as a leading jurisdiction for basing E-business developments.
- To formalise and implement initiatives designed to reduce any digital divide on the Island.
- To develop and implement targeted initiatives aimed at attracting further inward investment by e-businesses.

Issues identified in consultation with stakeholders and at the workshops include:

- Financial off shoring services are seen as both a threat and opportunity for the economy
- Energy costs to business will be a significant threat for the future, together with travel costs for personal, business use and goods
- The retention of skilled people, gaining work permits and the provision of tertiary level education.
- The 'quality of life' on the Island is high and this is often cited as giving the Island a competitive advantage.. However increasing costs, standards for infrastructure and services affecting the standard of living could impact on this and have knock on effects.

The workshops concluded that the key problem to be explored is:

How can the Isle of Man sustain continued economic growth in the face of climate change?

When considering the problem the following should be taken into consideration:

- Income per capita
- Global markets
- Future socio economic scenarios
- Population structure
- Maintain international competitiveness
- Quality of life on the Island

The Government's strategic policies for business and the economy of the Isle of Man are not related to climate change or current climate variability.

The economic impacts of climate change on the Isle of Man may also be determined by climate change elsewhere. The impacts will also be affected by wider changes in society and economies. Local business with a direct relationship to the climate (tourism, agriculture, fisheries etc) will need to consider the climatic changes on the Isle of Man.

Severe weather has significant impacts for the Isle of Man, for example, flooding of commercial centres in Douglas and transport service disruptions.

Activities ongoing on the Island

- Energy audits are being undertaken by many businesses
- Business continuity planning – some financial service companies are already looking at this

Stage 3: Business and the economy impact matrix

(note additional impacts are identified in technical paper 9)

Climate change risks			
Business	**Potential risks and opportunities**		
	Economy	**Financial Services**	**General**
Increasing summer temperatures (H)	• Tourism impacts (A) • Opportunity to sell the Island – quality of life • Increasing risk of fog will have adverse impacts on air and sea travel (A)	• Cooling buildings – major problem (A)	• Productive work time reduced (A) • Health and safety impacts (A) • Environmental health risks (A) • Food preparation risks (A) • Property damage due to subsidence and increases in insurance costs (A)
Increasing winter temperatures (H)	• Promoting the good quality of life on the Island (opportunity) (A)		• Reduced energy costs in winter
More extreme high temperatures (H)		▪ Indirect impacts from outside /external climate change impacts on the Island (A)	• Property values decrease as increase in subsidence (A)
Less extreme low temperatures (H)			• Impact on workspace (A) • Improved outside working conditions (A)
Higher winter rainfall (H)	• Increased risk of flooding in urban areas (A) • Disruption to travel (A/0)		
Less summer rainfall (M)			• Availability of water supplies for manufacturing e.g. food processing (A)
More intense downpours (H)		• Increase in insurance costs (A / O)	• Property values decrease as increase in flooding (A) • Increase in insurance costs (A / O)
Sea level rise and increased coastal flood risk (H)	• Risks to property – location of development (A)	• Major problems for financial services in Douglas (A)	• Business continuity planning (A)
Possibly more winter storms (L)	• Property damage (A) • Travel disruption (A) • Increasing insurance costs (A)		• Business continuity / disaster recovery is an opportunity to exploit (A) • Communications disruption (A) • Power outage, disruption of energy supplies (A)

Key
A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies / source providence unclear R = Research work has been undertaken that demonstrates this impact Confidence levels (based on the UKCIP02 scenarios[9]) H = High M= Medium L = Low

Stage 4: Business and the economy adaptation options

(note additional adaptation options are identified in technical paper 9)

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Introduce legislation to ensure all business and infrastructure issues have climate change as a key issue • Lifetime costs through planning / building regulations e.g. drainage specifications (win win) • Change building regulations so that properties can withstand more extreme conditions	• Building energy conservation (Design and installation) (No regret) • Legislation	• Planning / building design requirements (low regret)
	Research / Data collection / Monitoring	• Improve monitoring of rainfall and runoff	• Develop heat exchange systems • Use of tidal variations to generate tidal power • Alternative energy sources	
	Educational / Behavioural change / Awareness raising / working in partnership	• Health and safety awareness e.g. sun block for outside workforce • Education of energy conservation • Increase awareness within all sectors of business • Energy audits of business	• Cancer awareness training • Change to working conditions – education • Working conditions – new clothing / sunscreen (share loss)	• Change of working hours (no regret) • Plant trees to provide shade (win win)

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Increase tax on property owners who live in area of risk	• Develop alternative energy sources • Change in working day / change in building design	• Other islands are at greater risk – watch and learn
	Accept impacts and bear Loss	• Business continuity requirements – risk based management (win win)	• Stockpile essential supplies (e.g. oil)	
	Prevent effects: structural / technological	• Risk assess existing assets to identify investment required (win win) • Diversification of business by utilities (flexible) • Undertake flood risk assessments on all new builds	• All electrical systems should be put at dado rail levels • Put cables underground and not overhead	
	Avoid / exploit changes in risk	• Link river monitoring to all island alarm system (link flood defence and tides to same alarm)	• Sustain island's growth to afford changes e.g., creativity in business, tax and incentives. • Improve extreme weather reporting – advanced warning system	

acclimatise commentary

One of the reasons why the Isle of Man has been so successful in attracting inward investment and foreign / offshore business is through its reputation of having a high quality of life associated with its landscape, socio-environmental and economic systems. The effects of climate change on the Island will impact on many of the contributing factors to the quality of life and character of the Island, which will indirectly affect the economy and business as a whole.

Existing building premises including shops, offices and factories are designed to historic climate standards. In existing warm spells people already experience uncomfortable conditions in their place of work. The impact of climate change will exacerbate this impact particularly in hotter, warmer conditions. Internal temperatures above 25°C will become more frequent, the temperatures above which performance and business productivity drops and employees complain about their working conditions.[12]

Companies with staff working outside will need to consider the health and safety implications of increasing temperatures and exposure to UV radiation. Food preparation, public health and hygiene issues will become an increasing issue under higher temperatures during both winter and summer.

All business should be aware of the increasing risk of disruption to support services, including transportation. Even if not affected directly – business may suffer through indirect effects to their supply chains (both on and off the Island).

Businesses will face increasing insurance premiums resulting from disruptions to their business and damage to their property and assets. Businesses need to adopt a risk management approach to ensure their processes and operations are resilient to climate threats and to make the most of opportunities arising.

An interesting feature of the Isle of Man's economy is its openness – in that the bulk of income used to fund domestic consumption is generated from exporting goods and services (primarily financial services). The performance of the island's economy is therefore strongly linked with global events and economic conditions in trading partners (particularly in the UK). Further consideration of the effects of climate change on global economic issues and the consequential impacts on the Isle of Man is provided in technical paper 9.

The Isle of Man, in comparison with some other offshore financial service centres around the world, is likely to be at a lower risk from the effects of climate change e.g. the Cayman Islands and the Bahamas. This may provide the Island with a growing competitive advantage and increasing attractiveness to international financial services companies. It can be expected that that such companies when carrying out their due diligence before locating to the Isle of Man, will assess government strategies and climate risk management measures before relocating or continuing business on the Island.

Businesses face different risks as a result of climate change, depending on the markets in which they operate and their geographic location. There are essentially five broad categories of climate-related risk to which businesses (and investors) are exposed:

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[12] Hacker, JN, Belcher, SE & Connell, RK (2005). Beating the Heat: keeping UK buildings cool in a warming climate. UKCIP Briefing Report. UKCIP, Oxford.

- **Regulatory Risk**: Policy measures adopted at the international, national and local level will have direct (financial) implications for businesses and sectors.
- **Physical Risk**: The physical impacts of climate change (including storms, floods, droughts and sea level rise) will directly affect some sectors and businesses – especially those that are heavily dependent on the physical environment, water and weather. Sectors at particular physical risk include: agriculture, insurance, real estate, tourism, water, health care, and transport.
- **Litigation Risk:** Just as the tobacco and asbestos industries faced lawsuits for the impacts they caused, it is always possible that businesses responsible for significant amounts of greenhouse gas emissions could be held liable for damages arising from climate change. Failure to take into account a changing climate will place Companies, directors and their professional advisors at risk of future legal action.
- **Competitiveness Risk:** Businesses that fail to proactively take measures to adapt and mitigate climate-related risks may place themselves at competitive disadvantage relative to competitors that do so.
- **Reputational Risk:** Businesses that are viewed negatively may find themselves damaged in markets where the general public is concerned about climate change.

These potential risk exposures need to be recognised both at Government and at corporate levels and included within risk assessment procedures.

Examples of potential risks

- Increasing insurance and regulatory costs for business
- Impacts of climate change on regional and worldwide markets for financial services
- Business continuity
- Health and safety implications for workforce
- Disruption to business and supply chains and transportation systems by extreme events

Examples of potential opportunities

- Indirect impacts from outside /external climate change impacts on the Island – Isle of Man may have a competitive advantage
- Opportunity for the Isle of Man to provide business continuity support facilities for major financial companies affected by extreme events around the world.
- Changing markets and demands for good and services

Potential adaptation options

- Due diligence and corporate governance procedures to include climate risk assessments
- Stress-testing decisions against alternative climate scenarios
- Planning and design requirements for buildings
- Assess potential costs over a longer time horizon
- Awareness raising within the business community

4. Tourism

Characterisation

The Island's tourist market has moved away from the traditional main family holiday market and is now focused on short breaks and "niche" sectors including special interests and events e.g. the TT races, heritage, conferences, culture, other leisure activities or general enjoyment of the countryside. .

Tourism contributed over £110m to the Isle of Man economy in 2004. Tourism marketing efforts emphasise the landscape value and the environment of the Isle of Man. Adverse climate change impacts on these sectors will have a significant knock on effect on the industry. Over 3000 jobs are supported by tourism or tourist related industries.

An important issue to consider is that the financial services sector also relies heavily on many support services whose primary function was to support tourism, e.g. shopping, accommodation, restaurants, transport etc.

The Department of Tourism and Leisure is responsible for marketing activities both on and off the Island. The Department owns a substantial property portfolio and plant infrastructure including the Villa Marina and Gaiety Theatre Complex, the National Sports Centre, the Wildlife Park and bus and rail networks, vehicles and buildings. Recent developments that have been completed include refurbishment of the airport (£11m) – under the stewardship of the Department of Tourism - and the National Sports Centre at Douglas (£20m) and the refurbishment of the Villa Marina (£15m). Extensive investment has taken place in new facilities, accommodation, retail shopping developments and other aspects of the basic tourist infrastructure.

Some companies have diversified e.g. the Laxey Towing company operates a tourist boat in summer in addition to its marine support activities, providing an all year round business. Another example is the company Protours who provide coaching holidays as well as running school buses.

Various tour operators provide holidays direct to the Isle of Man. These are mainly orientated at the short break market.

Stage 1 and 2: Tourism

Defining the issue
Tourism
Response

Tourism plays a critical role in supporting the other sectors of the economy on the Island and also makes a significant contribution to the Island's economy.

The aim of the Department of Tourism and Leisure is to support the industry in order to grow the contribution tourism makes to the economy. The main objectives are to increase tourism throughout the year and develop the conference market. The aim is to attract a 'wealthier' tourist trade and as a result increase spending per visitor. A key area that was identified for improvement is the quality of existing accommodation and the provision of what are known as 'comfort factors'. A new Tourism Bill is currently being developed to be brought forward during the next parliamentary session.

Competition from destinations outside the Island was seen as an issue and linked to this was the requirement that accessibility on and off the Island needed to be improved. This included adding more entry routes, minimising waiting times and ensuring that the cost of travel is reasonable.

The Douglas Promenade area is the most important area for tourist accommodation. Many buildings are already susceptible to flooding from storm surge. The tourist industry is affected generally by business disruption during such events. Issues identified in the Department's tourism strategy include:

- The Douglas Promenade redevelopment
- The redevelopment of the Summerland site, although there are no firm plans for the future of the site as yet.
- Identification of future maintenance needs and costs for older buildings to try and understand whole life costs.
- The TT centenary celebrations in 2007.

Repeat visits are an important source of income and contribute significantly to the number of visitors to the Island. Cost of travel to and from the Island was identified as being a significant factor in attracting visitors to the Island, together with the need for large hotels and a diverse tourism industry. The stakeholder workshops considered that climate was not an existing major issue for tourism.

The current strategy is to attract high-income spenders, but this needs to be supported by the right product development and marketing, excellent accommodation, transport and services. Standards of service and quality within the tourism, retail and leisure are seen as important contributors to the success of this strategy. There is recognition of the need for the government support in investment and industry training schemes – such as the Manx Welcome Program, for those working in the hospitality industry.

Although climate change is not an existing main issue, the workshops identified areas where climate is already an issue, e.g. accommodation susceptible to flooding in Douglas. The stakeholders considered that climate will become more of an issue with potential beneficial impacts on demand, although these may be countered by issues of accommodation standards, environmental quality etc..

The stakeholders at the workshop decided that the issue for consideration should be:

How can we provide the required infrastructure both now and in the future to support the growth of tourism in the face of climate change?

When considering the problem the following should be taken into consideration:

- Future development
- Maintenance of existing infrastructure
- Potential opportunities

Stakeholders include: hotel and guest houses etc., the Department of Tourism and Leisure, business, private sector developers, general public, visitors to the Island, development and planning stakeholders, trade and industry representatives, NGOs, DTI, Film Industry, Chamber of Commerce, hospitality industry and tourism associations, retail sector, transport services, leisure facilities, and museums

<u>Government objectives</u>

- Stimulate sustainable tourism to optimise long-term benefits for the Island
- Make a significant contribution to the Island whilst projecting a positive national identity

<u>Government Indicators / measures for these objectives could include:</u>

- Visitor satisfaction surveys e.g. repeat bookings.
- Visitor spend
- Bed space information – occupancy levels
- Equivalent advertising value (EAV) of UK press articles
- Awareness and perception of the Island as a visitor destination

Stage 3: Tourism impact matrix

Climate change impacts			
Tourism	**Potential risks and opportunities**		
	Related services (e.g. restaurants, accommodation)	**Tourist activities (e.g. nature tourism, marine, eco-tourism, golf etc)**	**General**
Increasing summer temperatures (H)	• Improved transport needed to support tourism (A) • Extended season opportunity (A) • Existing accommodation cannot cope with increased extremes and becomes uncomfortable (A) • Increased heat in visitor facilities (A) • Toxic algal blooms are already monitored and shellfish poisoning as could become an issue for tourist eating shellfish. The main scallop fisheries can get closed due to algal blooms (A / O) • Expansion of café culture and outdoor dining (A) • Increasing risk of food poisoning due to inadequate food preparation and storage procedures (S)	• More marine activity opportunities (A) • Outdoor and water based activities increase (A / S) • Stressful for mammals (A) e.g. Curraghs Park • Drying of moor land – change of vegetation (A) • Effects on coastal water quality – increase in algal blooms / jellyfish numbers and beach management may have negative effect on tourism (A / S) • Algal blooms may effect water colour so having negative impact on water based activities (S)	• Island becomes less attractive / beautiful. (A) • Greater demand on water resources from TT races as more tourists. (A) • Increase burden on health service from tourists – of sunburn and exposure to heat. (A) • Increased fire risk in upland areas (O / R) [13] • Implications for emergency services (A) • Air quality concerns and impact on respiratory illnesses (A) • Increase in intensity and frequency of extreme events elsewhere e.g. heat waves, may increase the demand for UK based tourism (S – South west) • Increasing energy costs to keep buildings and accommodation cool (A) • Increasing energy costs to maintain temperatures in food preparation and storage areas (A)
Increasing winter temperatures (H)	• Lower energy costs for facilities as a result of lower heating demands	• Impact on fisheries (A) • Increased demand for short breaks in winter (S) • Need for all year round tourist and leisure facilities – no / reduced close season (S)	
More extreme	• Different menus (A)	• Changes in our landscape may affect eco-	

[13] Climate change and the visitor's economy. Challenges and opportunities for England's Northwest. (2000). Sustainability Northwest (Manchester) and UKCIP (Oxford). McEvoy, D; Handley, J; Cavan, J; Aylen, J and Lindley, S.

high temperatures (H)	• Increase in food poisoning as higher temperatures result in higher levels of bacteria (S)	tourism and other outdoor activities (A) • Drought effects on gardens / tourist attractions (S) • Recreational fishing may suffer in dry summers (S)	
Less extreme low temperatures (H)	• Increase in tourism – potential to exploit opportunity (A)	• A longer, more reliable summer season and warmer winter, thus extending the tourism season (S)	
Higher winter rainfall (H)	• Infrastructure damage due to intense precipitation events – increased risk of flooding (0)	• Wetter winters may be unattractive to visitors countering warmer temperatures (A) • Hotels on Douglas promenade already have damp basements / cellars and are prone to flooding (A) • Cultural sites such as Rushen Abbey and Castletown could become more vulnerable to flooding (A) • Impact of erosion of footpaths (A)	
Less summer rainfall (M)	• Potential decrease in water resources available (A) • Decrease in water quality (A)	• Increasing risk of fires in upland areas (O)	
More intense downpours (H)	• Infrastructure damage due to intense precipitation events – increased risk of flooding (0)	• Saturation of grounds e.g. sports facilities resulting in increased drainage impacts management costs and reduced usage (S)	
Sea level rise and increased coastal flood risk (H)	• Infrastructure damage due to increased risk of flooding (0) • Impact on transport services	• Impact on marinas (A)	• Loss of amenities e.g. beaches (A) • Loss of beach – Port Erin (A) • Loss of Douglas Promenade (A) • Loss of heritage sites especially Castle Mona Hotel (A) • Sea level rise and flooding threatening coastal and riverside facilities (S)
Possibly more winter storms (L)	• Service disruption (A) • Sea travel difficult – boats need to be adapted (A)	• Impact on cruising boats and activity holidays (A)	
General		• Basking sharks generate tourism, however will they be there under climate change (A) • Tourism – sea fishing is popular – how will this change (A)	• Opportunity for diversification – new markets and job creation (S)

		• Opportunities for increased prestige and marketing based upon specialist tourism e.g. green tourism (S)	

Key
A = Accepted wisdom / Anecdotal evidence
O = Observed, the impact has already been seen
S = Information obtained from other scoping studies: source = providence unclear
R = Research work has been undertaken that demonstrates this impact

Confidence levels based on the UKCIP02 scenarios[9]

H = High
M= Medium
L = Low

Stage 4: Tourism adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Ensure that climate change impacts are considered in refurbishment of accommodation • Review building regulations • Review land-use planning policies to encourage farm diversification and development of holiday accommodation (win-win)	• Provide incentives for more environmental friendly take away food packaging (low regret) • Monitor and review food hygiene, preparation and storage procedures – introduce new standards	
	Research / Data collection / Monitoring	• Monitor changes to identify and promote new opportunities • Landscape assessment to identify at risk areas and tourist 'carrying capacity' (No Regret) • Review impacts on tourist accommodation (win-win)	• Research on impact of climate change on golf course maintenance (win win) • Market research on future opportunities for tourism, e.g. marinas, eco-tourism, short-breaks, culture, conferences (no regret)	
	Educational / Behavioural change / Awareness raising / working in partnership	• Education regarding moor land fires and the potential impacts • Review tourist industry staff training schemes	• Identify best practice examples and raise profile of Island (win win)	• Continued professional development – could consider climate change as part of CPD for tourism and related industries

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Design in cooling mechanisms for buildings in new build.	• Unreliable ferry service in variable weather (low regret)	
	Accept impacts and bear Loss		• Introduce air conditioning in hotels and guest houses – accept energy costs and potential emissions impacts (flexible) • Loss of amenity in some areas will be irreversible e.g. specific beach locations and specific buildings. Maintain for as long as possible.	
	Prevent effects: structural / technological	• Introduce measures to provide further protection of landscape i.e. footpath erosion and fire risk • Ensure IoM airport runway extension – takes into account future climate impacts (low regret)	• Plan for effective water supplies under drier summer conditions (win win) • Design engineering solutions to address risk of transport links being disrupted by flash floods / erosion • Allow for sea level rise in harbour development (low regret) • Encourage improvements to buildings to cope with excessive heat in summer and / or wet weather in winter • Develop TT road surface and facilities to withstand extreme temperatures, precipitation etc.. (win-win)	
	Avoid / exploit changes in risk	• Encourage diversification of agriculture industry to provide more accommodation (low regret)	• Focus marketing on positive impacts arising from climate change (win-win) • Exploit higher summer temps and opportunities for increase in demand for tourism (win win) • Opportunities for specialist holidays with outdoor activities Make best use of landscape ecological change to maintain recreational use of the landscape. Adapt locations and activities (win win) • Motor sports may need to refocus for weather infrastructure reasons • Develop / expand facilities for water based recreation (win-win) • Specialised holidays by changing land use and diversifying into habitats for key species. (win win) • Provide fiscal incentives to tourist industry to improve accommodation (win-win)	

acclimatise commentary

The risk of flooding in Douglas and its potential impact on tourism is already an issue for the Isle of Man. The risks and the financial costs will increase under the climate change scenarios. (In technical paper 7 an analysis of the potential costs of an extreme event has been undertaken which will provide further guidance on this issue). Increasing summer temperatures and more extreme high temperatures will have implications for the cooling of buildings (accommodation, leisure and tourist attractions, restaurants etc.) Designing in climate resilience now will ensure that the infrastructure is robust for the future.

The tourist sector is reliant upon supporting services and infrastructure on the Island, which also need to be resilient to climate change. If climate impacts are not considered then the levels of services to tourists and visitors may decline. Increasing temperatures for example will have impacts for food hygiene, food preparation and storage; maintaining high standards in these areas is vital if the Island is to meet its strategy of developing a tourism industry based on high-income visitors.

Baseline data indicates that the tourist sector is currently less reliant on good weather as most visits to the Island are event or activity driven. Increases in temperatures throughout the year together with a warmer and prolonged summer season may provide additional opportunities to develop tourist related events and activities. However there may be disadvantages associated with increased visitor numbers, e.g. impact on transport infrastructure and other supporting services.

Tourism is intrinsically linked with the natural resources and landscape character of the Island. Changes in these areas will have impacts upon the industry. Increases in tourism will also in increase the stress upon these areas. A recent study undertaken in the north-west of England[14] highlighted the consequential risks for the environment, e.g. footpath erosion, heath and moorland fires, associated with a changing climate and increasing visitor numbers.

The study also noted:

> "Until recently, the common belief that the warmer, drier summers brought about by climate change would stimulate a boom in visitor numbers, has not been questioned. However, the relationship between climate and visitor demand is complicated, and the economic opportunities may not be this straightforward. Although based on limited data, the research findings suggest that recreational behaviour in the Northwest appears to be fairly resilient to the weather – this resonates with other recent research findings internationally. Climate influence on visitor behaviour is more likely to be overshadowed by socio-economic trends, particularly how we choose to spend our leisure time in the future."

[14] McEvoy, D., Handley, J. F., Cavan, G., Aylen, J., Lindley, S., McMorrow, J. and Glynn, S. (2006). Climate Change and the VisitorEconomy: the challenges and opportunities for England's Northwest,Sustainability Northwest (Manchester) and UKCIP (Oxford).

Examples of risk

- Visitor facilities and accommodation may need to be upgraded to provide expected levels of service under higher temperatures.
- Increased risk of upland fires
- Increase in the risk of food poisoning arising from the impact of higher ambient air temperatures on food hygiene, preparation and storage.
- Impact of storm surge on main accommodation areas in Douglas.

Examples of opportunities

- Expansion of café culture and outdoor dining
- A longer, more reliable summer and warmer winter extending the tourist season
- New markets in specialist activity/event holidays based on water sports/leisure and eco-tourism

Potential adaptation options

- Fiscal incentives to encourage improvements to buildings to cope with excessive heat in summer and / or wet weather in winter
- Monitor and review food hygiene, preparation and storage procedures – introduce new standards
- Landscape assessment to identify at risk areas and tourist 'carrying capacity'
- Review land-use planning policies to encourage farm diversification and development of holiday accommodation

5. Society and culture

Characterisation

The resident population is currently approximately 76,000 with 31,500 households. Douglas accounts for over a third of the resident population and over 32% of households. Recent government policies aimed at attracting people of working age to the Island has had an effect on correcting an imbalance in the demographic age profile, reflecting the large percentage of retired people in the resident population.

The age structure currently is:

- children (0-15): 19%
- working age (16 –64 – Males; 16 –59 –females): 61.7%
- retirement Age (65+ Males; 60+ females): 19.3%

The immediate priority for the government is the development of a strategy for children and young persons, which delivers co-ordinated action across relevant and public sector agencies.

Events celebrating the Manx culture such as Yn Chruinnaght (inter celtic festival), Cooish and Shennaghys Jiu are supported and promoted across the Island. One of the most important events is Tynwald Day. These events not only serve to promote and protect the Island's unique culture and heritage but also play a role for the tourism industry.

The Island has achieved a reputation for educational excellence and strives to maintain this reputation. The Government, through the Department of Education, is responsible for the provision of school age education on the Island, and plays an important role in the provision of tertiary education. There are strong links with the UK in education issues including, curricula, public examinations, the use of external inspectors, and teacher training.

Fifteen non-Tynwald members make up the Board of Education, which is elected every five years. The main purpose of the Board as a collective body is to advise and submit recommendations to the Department of Education on matters of educational policy and the needs of the statutory system of public education on the Island.

Education infrastructure covers:

- Primary Schools: 35 schools; ~6,600 pupils
- Secondary Schools: 5 schools; ~5,600 pupils
- Isle of Man College: 735 full-time students, 4,633 part time vocational and 2,932 part time recreational and leisure.
- Other: 18 play clubs, 24 youth clubs, 28 special projects.
- 2 Outdoor Education centres, other centres (music, in-service training, career centre)
- Noble Hall Library and Mobile Library
- International Business School
- 1,200 students supported at university's in the UK and in other countries

Stage 1 and 2: Society and culture

Defining the issue
Society and culture
Response
Education is the building block for the future of the Island and continued economic progress. A key strategy for the island is to continue to improve the lives, health and welfare of all young people and children. Protecting and developing the Island's national identity and cultural heritage underpins many of the Government's strategies. Achieving international recognition and acceptance of the Island's unique constitutional, cultural, commercial and social identity is a key policy. The main objectives are to raise the standards of schools even further and support school improvement. A key part of this is also to respond to changes taking place outside the Island that will affect Island residents. Information, communication and technology (ICT) is an important part of education provision and there is a need to continue to develop high levels of access to and use of ICT. Consideration is being given to the construction of a new secondary school to meet increasing student numbers. Upgrades and improvements of existing schools are also being considered. The stakeholder workshop defined the key issue as: **How can we provide the required educational skills and environment so that the Island can survive, prosper and achieve economic growth in the face of climate change? How can we preserve the quality of life on the Island in the face of climate change?** When considering this issue the following should be taken into consideration: ▪ IT infrastructure ▪ Education buildings ▪ Awareness raising ▪ Future business requirements ▪ Protection and development of Island's national identity ▪ Encouragement to stay on the Island – maintaining the high quality of life ▪ The impact on different ages ▪ Communications ▪ Social support systems – the role of the voluntary sector Although climate change is not the main driver for the current issues confronting society and culture on the Isle of Man. the services and infrastructure that supports this sector can and will be affected. Maintaining the high living standards and the Island's reputation for its quality of life are essential. These are seen as providing the Island with a competitive advantage in attracting investment, new businesses, and skilled employees, and in the development of the tourism industry.

Stage 3: Society and culture impacts matrix

Climate change risks		
Society and Culture	**Potential risks and opportunities**	
	Quality of Life	**Supporting Services**
Increasing summer temperatures (H)	• Lifestyles and health may benefit from a move to a more outdoors culture throughout the year, providing that the potential adverse health impacts from increased exposure to sunlight and air pollution are limited (A) • Increased temperatures in urban / public areas (A) • Café culture could be developed (A) • More outdoor activities undertaken (A) leading to a healthier population	• Buildings become uncomfortable to work in, schools in particular are not designed to cope with higher temperatures (A) • Employee efficiency levels decrease in hot temperatures (O) • School playgrounds do not have sufficient shade cover (A)
Increasing winter temperatures (H)		
More extreme high temperatures (H)	• Impact on vulnerable sections of society: the elderly, young children, those with respiratory illnesses (O)	• Overload voluntary sectors – ability to cope (O)
Less extreme low temperatures (H)		
Higher winter rainfall (H)		
Less summer rainfall (M)		
More intense downpours (H)	• Increased flooding can be stressful in particular to children. Such behavioural and emotional impacts are likely to affect children's educational performance [15] (S)	
Sea level rise and increased coastal flood risk (H)	• Physical disruption to life during and following an extreme event • Impact on reputation of Isle of Man – extensive (potentially adverse) media coverage of an extreme event	• Disruption to social and cultural systems • Overload voluntary sectors – ability to cope
Possibly more winter storms (L)	• Physical disruption to life during and following an extreme event • Impact on reputation of Isle of Man – extensive (potentially adverse) media coverage of an extreme event	• Disruption to social and cultural systems • Overload voluntary sectors – ability to cope

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R = Research work has been undertaken that demonstrates this impact

Confidence levels based on the UKCIP02 scenarios[9]
H = High M= Medium L = Low

[15] Shackley et al (2001) Changing by Degrees: The potential impacts of climate change in the east midlands

Stage 4: Society and culture adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	▪ All new builds need to be climate proofed ▪ Define building standards for comfortable indoor environments		
	Research / Data collection / Monitoring	▪ Research on how to deal with flooding stress and supporting services that might be required ▪ Identification of vulnerable groups in society and action plans developed for extreme events ▪ Develop a policy on 'sustainable' schools – test policies against climate scenarios	▪ Identify buildings at risk – unable to provide comfortable indoor environments ▪ Undertake research into and then monitor Isle of Man quality of life indicators	▪ Examine potential correlation between 'climate change' and 'quality of life' indicators
	Educational / Behavioural change / Awareness raising / working in partnership	• Climate change can be an interesting and informative topic for the curriculum. It covers a range of topics and can be approached quantitatively and qualitatively • Awareness raising of heat stress		
Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Provide shade in school playgrounds / trees on streets and provide more shade in public areas. • Develop and implement action plans for dealing with vulnerable groups in society in the event of extreme events		
	Accept impacts and bear Loss			
	Prevent effects: structural / technological	• Ensure IT equipment is protected from heat and floods	Retrofit existing buildings to withstand extreme high temperatures and warmer summers	
	Avoid / exploit changes in risk		• Change in scheduling of the school day, - starting earlier and earlier finish • Introduce more flexible working hours in summer months	

acclimatise commentary

There is a strong national identity on the Island and this should be considered an important aspect when considering climate impacts. The determination and pride in the Manx national identity has created a natural resilience, which may prove to be of wider benefit in meeting the challenges of climate change. Small island states are often acknowledged as being particularly exposed to the potential impacts of climate change, a point noted by the Intergovernmental Panel on Climate Change (IPPC):

'small island states clearly are a vulnerable group of countries and hence are significantly at risk from climate change'[16]

The Isle of Man's unique political, social and economic position with regard to the UK and the EU has led to the development of a culture of 'adaptive capacity' and self-reliance. This culture, supported by a strong national identity and natural resilience, will help the Island adapt and manage the climate risks and opportunities.

Social changes play a significant role in how much impact climate change will have on the Isle of Man, as already demonstrated in technical report 6 which looks at the impact of future socio-economic scenarios.

Education plays a vital role in securing the future of the Island. Raising awareness within children is a major adaptive action. The Isle of Man should carefully examine opportunities for building adaptive capacity through education.

Further research on the affect of a changing climate on social services and support organisations (particularly the voluntary sector), social structures, and on the culture of the Isle of Man is desirable.

Examples of risk

- Impacts on vulnerable sections of society: the elderly, young children, and those with respiratory illnesses
- Impact on reputation of Isle of Man – extensive (potentially adverse) media coverage of extreme events
- Voluntary social service and support organisations ability to cope in extreme events

Examples of opportunities

- Lifestyles and health may benefit from a move to a more outdoors culture throughout the year, providing that the potential adverse health impacts from increased exposure to sunlight and air pollution are managed
- The Island's response to the challenge of climate change may reinforce 'national identity'

[16] IPPC Intergovernmental Panel on Climate Change reports http://www.ipcc.ch/

Potential adaptation options

- Identification of vulnerable groups in society and action plans developed for extreme events
- Engaging children through the education curricula. Climate change can be an interesting and informative topic for covering a range of topics and can be approached quantitatively and qualitatively.
- Examine potential correlation between 'climate change' and 'quality of life' indicators

6. Historic environment

Characterisation

The Isle of Man is set in the Irish Sea, midway between England, Scotland, Northern Ireland and Wales. It is also known also as "Mann" and has the oldest continuous parliament in the world called Tynwald.

Manx National Heritage is the national heritage organisation for the Isle of Man, recognised as a unique organisation in Europe for the range and quality of its service to the community. Manx National Heritage (MNH) has a role in providing to the people resident in the Island, its visitors, and particularly the young, accurate information and knowledge about the history, culture and development of the Island. The promotion of the Island's history draws together the National Museum Service with 13 major interpretation sites, an increasing National Trust landholding, the National Art Gallery and National Archives and Library. The development of these links plays an increasingly important part in helping to develop the Island's international identity and image.

A new heritage centre, the House of Mannan, was opened at Peel in 1997, to present the Island's Viking, Celtic and maritime history. It enhances "The Story of Mann" – which is marketed throughout the UK and abroad by the Department of Tourism and Leisure in conjunction with Manx National Heritage.

A number of historic sites have been developed to support the growing interest in the Island's historic culture, including the Manx Museum, Peel Castle, Castle Rushen, the old Grammar School, the Nautical Museum, Rushen Abbey, Cregneash Folk Village, Grove House and gardens, the Great Laxey Wheel and mines trail and the old House of Keys.

The development of these services has been made possible by the strong support of the Manx Government and the Friends of Manx National Heritage. There are also academic studies, which can be undertaken within the Centre for Manx Studies, in partnership with the University of Liverpool and the Department of Education.

Important international heritage links are being developed, for example, with Norway and other "Viking Heritage" regions and the development of the new Agreement for Cultural Co-operation with the UK Museums.

Stage 1 and 2: Historic environment

Defining the issue
Historic environment
Response
Manx National Heritage exists independently by Statute on behalf of the Manx community to preserve, protect, promote and communicate the unique qualities of the Manx natural and cultural heritage. Three key objectives of the Manx National Heritage are: • community involvement in Manx heritage to a level which guarantees the permanent retention of these unique assets for the benefit of present and future generations, thereby providing for the continuing security of the Manx identity. • a platform for national pride and concern for the Island's heritage which is actively promoted to the Island's educational community at all levels in a positive and enriching way. • a focus for marketing the Island in a prestigious and attractive way by presenting an image of one of the most concentrated and best cared for historic landscapes in Europe. The need to ensure the cultural and historic basis of Manx identity remains a prime objective of Manx National Heritage, together with the development of opportunities to promote the international prestige and image of the Island. The 2002 storm surge highlighted current vulnerability of heritage (built and non-built) especially in low-lying areas. The 'save all' approach to the historic environment needs to be re-evaluated. It is not realistic to conserve anything forever or everything for any time at all. Value and significance must also be part of future planning of the historic environment faced by a changing and worsening climate.

Stage 3: Historic environment impacts matrix

Climate change risks		
Historic Environment	**Potential risks and opportunities**	
	Materials	**Site Location**
Increasing summer temperatures (H)	• Longer sunlight hours can increase the photochemical degradation of polymers used in both modern construction and the restoration of ancient buildings[17] (R) • Building decay accelerated as a rise in temperature could lead to an increased rate of chemical attack on certain structures and fabrics (R) • The drying out of historic fabric is far more complex than modern buildings. Much of it cannot and must not be replaced after water damage.[18] (R)	
Increasing winter temperatures (H)		• Insect damage and vegetation growth may increase. A warmer climate may introduce new pests into the country or stimulate the movement of current problem species. Being aware of such potential problems would mean that preventative measures suitable for heritage structures and materials could be introduced before pests become established within them [18] (R)
More extreme high temperatures (H)		• Drier compacted soils are likely to increase the risk from subsidence; therefore vulnerable sites will require stability assessments and protective measures [18] (R)
Less extreme low temperatures (H)		
Higher winter rainfall (H)	• Alteration in seasonal and annual rainfall will change the length of time during which surfaces are wet, affecting surface leaching and the moisture balance that influences material decay processes.[17] (R) • In most materials, a rise in relative humidity causes an increase in deterioration, due to prolonged wetness time, higher deposition rates of pollutants and more favourable conditions for microbiological activities (R)	• Increased rainfall rates could cause serious site drainage issues from rising water tables, and higher levels of moisture and damp could increase biological attack or other forms of decay such as salt mobilisation [18] (R)

[17] http://noahsark.isac.cnr.it/ Global Climate change impact on Built heritage and cultural landscapes.

[18] UKCIP report: Building knowledge for a changing climate. The impacts of climate change on the built environment www.ukcip.org.uk

Less summer rainfall (M)		
More intense downpours (H)	• Increased winter rainfall and storminess, particularly in exposed areas, is resulting in water-saturated building fabrics.[17] (R)	• If changes in water table chemistry result from a fall in water table height, or from seawater incursion, certain areas may see a change in the pattern of damage from rising damp.[19] (R)
Sea level rise and increased coastal flood risk (H)		
Possibly more winter storms (L)	• An increase in wind velocity may affect materials deterioration in several ways. Increased eddies and flows around historic buildings can increase the deposition rates of both gaseous and particulate pollutants, as well as strengthening the effect of driving rain. A very serious effect may be an increased transport of sea salt inland, which can substantially enlarge the areas along sea coasts affected by marine aerosols.[17] (R)	• Potential changes in local wind regimes could cause increased structural damage and abrasion from airborne particles, together with moisture penetration problems from wind driven rain.[18] (R) • Many processes affecting the conservation of archaeological and historic sites do not occur at regular intervals, but are concentrated in episodic outbursts related to the presence of extreme events, such as severe storms, carrying both water and dust. As examples, frequent repetition of floods and windstorms accompanied with landslides and fires have affected large and rich cultural heritage areas, e.g. in Italy, Turkey, Bohemia. The frequency of flooding will increase in many areas of Europe.[17] (R)
General	• Elevated ultra-violet radiation levels and light intensity could result in increased deterioration of fabrics and materials.[18] (R) • Although legislation has greatly reduced concentrations of 'traditional' air pollutants in cities, the changing climate may enhance the effects of some of them. In particular, changes in wetting and drying cycles on building surfaces may alter the deposition of acidic gases onto the surface • Increasing atmospheric concentrations of carbon dioxide and other trace gases alter air chemistry and influence chemical reactions.[17] (R) • An increase in sun radiation may accelerate the deterioration of organic materials, such as paint coatings, and materials used for consolidation of stone materials[17] (R)	• Controlling pollution from increased agricultural run-off may also become a more serious issue for some buried sites.[18] (R) • Plant physiology and distribution changes were also a cause for concern. 'Changes in vegetation cover will greatly affect the survival of buried sediments and artefacts and ecofacts. Deep root penetration is very damaging to structures and sediment boundaries.' There may also be a problem of dewatering by transpiration, and loss of vegetation cover through drought could also exacerbate erosion.[19] (R)

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[19] Climate change and the historic environment. UCL . May Cassar. www.ucl.ac.uk/sustainableheritage/climatechange/climatechangeandthehistoricenvironment.pdf UCL center for sustainable heritage. Dec 2005.

Stage 4: Historic environment adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**			
	Research / Data collection / Monitoring	▪ Need to consider the susceptibility of different materials to the likely future climate. In terms of characteristics such as thermal capacity and moisture transfer, materials such as earth, stone or wood have widely varying responses to changing local conditions. Both external and internal finishes, such as painted finishes, may be affected in different ways. For structures built using traditional or unconventional construction techniques, we need to better understand these methods and how they can be refined for the future.[18] ▪ Record what's there before it goes - so have record for the future and prioritise protection measures ▪ Identify sites at risk from subsidence and vulnerable sites will require stability risk assessments and suitable protective measures ▪ Identify sites at risk from flooding and increasing winter water table levels / rising damp		
	Educational / Behavioural change / Awareness raising / working in partnership			
Delivering Adaptation	**Spread /Share loss**			
	Accept impacts and bear Loss	▪ Leave buildings as too costly too preserve		
	Prevent effects: structural / technological			
	Avoid / exploit changes in risk	▪ Put in structural methods to prevent inundation from floods / storms ▪ Move assets		

acclimatise commentary

Recent extreme events have highlighted the existing vulnerability of the Island's historic assets to the weather. Under climate change this vulnerability may be increased and further exacerbated by seasonal changes.

The impacts of climate change may question the 'save all' approach to the historic environment to be reviewed, as it may not be realistic to conserve all features for posterity, particularly those on coastal sites. Value and significance must also be assessed when reviewing the impacts of climate change to ensure that resources are used effectively.

Existing baseline data for each site should be reviewed to identify potential climate sensitivities and impact thresholds. A programme of historic site routine monitoring would allow deterioration rates to be tracked and provide further information on climate impacts.

There is a great deal of information regarding the impacts of climate change on the historic environment, although there is little supporting information on adaptation options. Further research and assessment of suitable options for individual sites or buildings is required. Although generic 'options' guidance will be beneficial, it is important that risk assessments are undertaken at a site specific level to identify the most appropriate adaptation action.

Examples of risk

- Building decay accelerated as a rise in temperature may lead to an increased rate of chemical attack on certain structures and fabrics
- Increased winter rainfall and storminess, particularly in exposed areas, resulting in water-saturated building fabrics
- Drier compacted soils are likely to increase the risk from subsidence; vulnerable sites will require stability assessments and protective measures
- Increase in damage from increasing visitor numbers

Examples of opportunities

- Increase in visitor interest in the Isle of Man's history and culture providing additional revenue
- Drier summers and changes in crop patterns may expose previously unknown archaeological sites

Potential adaptation options

- Need to consider the susceptibility of different materials to the likely future climate
- Identify sites at risk from subsidence - vulnerable sites will require stability risk assessments and suitable protective measures
- Identify sites at risk from flooding.
- Assess potential adaptation options.
- Review baseline data for historic sites and review against climate change impacts to identify knowledge gaps.

7. Health

Characterisation

The Isle of Man enjoys a comprehensive National Health Service with better standards than the UK. Healthcare takes a high priority in the Government's expenditure plans, reflected in the quality of the excellent services offered. The hospitals are well equipped and there are resident consultants in most specialities. Under a reciprocal arrangement with UK covering health and social benefits, new residents to the Island are entitled to the full range of health care services as soon as they take up residence.

The health services division general policy is to promote the establishment of comprehensive programmes of health promotion, treatment and care. These programmes are designed to secure improvement in the physical and mental health of the people of the Island, and the prevention, diagnosis and treatment of illness.

The social services division provides specialist advice, guidance, assistance and services to persons who are unable to sustain a reasonable quality of life.

Stage 1 and 2: Health

Defining the issue
Health
Response

Health and welfare are critical to the well being of the population. Health and Social Security delivers a national health service, social care programmes and the social security benefit system. The health department sees the key challenges are access to services, recruitment and retention of staff, the new GP, dental and pharmacy contracts, together with the health and well being of the population. Social security's key challenges include the provision of a modern benefits programme, promotion of benefits available, ensure IT is used to its best effect, incentives to work are continued, retirement income planning strategy is devised and unemployment is kept at low levels.

A new IT strategy is to be implemented to provide the required performance management information. The development of health infrastructure is defined to include upgrades and development of existing and new buildings.

On the Island, almost half the number of deaths is caused by diseases of the circulatory system (as in the UK and elsewhere). This category includes both Coronary Heart Disease and Cerebrovascular Disease. The next leading cause of death is cancer, accounting for around a quarter of all deaths in the Island (Information based on year 2000 in the Health Strategy 2003).

The key issue to be addressed is:

How can we deliver comprehensive programmes of health promotion, treatment and care to secure improvement in the physical and mental health of the people of the Island in the face of climate change?

When considering the problem the following should be taken into consideration:

- Air quality
- Increased sun exposure
- Infrastructure
- Effects on different population
- Damp houses and health
- Stress

It thought that there is already an issue with sun exposure as the incidence of skin cancer is higher than average when compared to similar regions in the UK. Hence this indicates that the problem to a certain degree may already involve managing present day climate. Data has not been able to be established for the influence of other present day climate variables.

The main driver is not climate change but as indicated above climate may already be a part of the problem and could potential become a larger factor

in the future. Increased temperatures could pose considerable risks as temperatures effect vulnerable populations. Increased temperatures can lead to higher mortality rates, increased air pollution problems and increased sun exposure.
Indirect effects may have to be dealt with such as stress from flooding events.

Key stakeholders are social services, the health service, Department of Health, GPs, Dentists, Doctors, Pharmacies and the general public.

The key objectives are:

- To maintain and, where necessary, improve the physical and mental health of the people of the Island through prevention and treatment of illness, disease and disability.
- To provide a comprehensive and readily available range of acute health services.
- To achieve greater awareness of the benefits of a healthy lifestyle.
- To provide a comprehensive programme of benefits, which is effective in, meeting genuine need, encourages independence and provides incentives to work.

The indicators / measures for these are:

- Monitor hospital waiting lists and take action as appropriate to achieve performance targets in relation to 'waiting times'
- Average number of deaths per year of persons under 75 as a % of total deaths.

Stage 3: Health impacts matrix

Climate change			
Health	**Potential risks and opportunities**		
Increasing summer temperatures (H)	• Risk of increased exposure to sun radiation (S)[2] • Increased risk of skin cancer (S) • Increased risk of heat exhaustion and dehydration (S) • Risk of heat stress in participants in summer sports (S) • Increased risk of food poisoning, including shellfish poisoning (A / S) • High temperatures have significant adverse effects on mortality and morbidity. In the UK, heat-related deaths begin to occur when mean daily temperature rises above the minimum mortality band of 15.6-18.6˚C.[20] (R) • Food poisoning is associated with warm weather. The predicted increase in UK temperatures is likely to be accompanied by an increase in cases of food poisoning.[20] (R)	• Increased need to emergency services on beaches to provide medical help for sun affiliation and water rescues (A) • Risk of heat stroke (S) • Increased risk of air pollution (A) • Increase risks of asthma attacks (A) • Possible increase in workplace accidents and heatstroke (A) • Reduction in the season for the RSV virus which has been ending about 2 to 3 weeks earlier for each degree rise in regional annual air temperatures, but rising temperatures have not affected the onset of the season. [21] (R) • Increase in road accidents (R)	• Need for more environmental health officers and laboratories to monitor abattoirs m food supplies etc for potential food risks (S) • Tendency towards eating healthier foods in warmer weather (S) • Fresh healthy and locally produced food available for a longer period (S) • More opportunities for outdoor activities, with associated health benefits (S) • Increasing visits to GP due to increase length of asthma season / increasing pollen in the air • Increase in hay fever as there may be an earlier start date for tree pollen and a more severe grass pollen problem[22] (O)
Increasing winter temperatures (H)	• Increased pests and vermin surviving the winters (A / S) • Reduced winter die off of bacteria and viruses (S)	• Less risk of accidental injury by slipping on ice (S) • The timing of spring budding has advanced in recent decades and hence	• Increased pollen production and increased plan reproductive effort under elevated CO2 conditions [23] (R)

[20] Health effects of climate change in the UK. Department of Health April 2001

[21] Donaldson,G.C. 2006. Climate change and the end of the respiratory syncytial virus season. *Clinical Infectious Diseases* **42**:677-679

[22] Article from independent online May13th 06. 'Why global warming is to blame for Britain's hay fever epidemic'

		the allergenic pollen season for spring flowering plants has also begun earlier[23] (R)	
More extreme high temperatures (H)	• Heat waves, unhealthy air masses, high heat indices (a function of temperature and humidity), plus lack of nighttime relief all affect respiratory and cardiac conditions and mortality.[23] (R)		
Less extreme low temperatures (H)	• Less ill health due to living in what are currently cold, damp conditions (S) • Less carbon monoxide poisoning due to a reduction in space heating requirements (S)	• Fewer deaths due to hypothermia (S)	
Higher winter rainfall (H)	• Increased incidence of mould growth and associated health risks (asthma, allergies etc), particularly in poorly heated / ventilated housing (S)	• Health risks associated with sewage systems overloads (S)	
Less summer rainfall (M)	• Risk of deterioration of water quality and supply (S)		
More intense downpours (H)	• Risk of long term psychological impacts on victims of flood events (S)	• Risk to life and health through property flooding (S)	
Sea level rise and increased coastal flood risk (H)	• Danger of being swept to sea by unexpected high tides and sea swells (S)		
Possibly more winter storms (L)	• Risk of personal injury due to falling or wind propelled objects, or damage to infrastructure, electric cables etc (S) • Limited risk of direct injury due to weather conditions (S)	• Personal injury from flying debris and falling trees is likely to increase[20] (R) • An increase in traffic accidents is also probable.[20] (R)	
Other	• Climate change will alter the timing, production and distribution of airborne pollen allergens. (R) • Increased exposure to water-related pathogens in other countries during travel from the UK.[20] (R) • Indirect effects due to increased exposure to water used in air conditioning e.g. *Legionella pneumophila*[20] (R) • Decreased quality of drinking water (A) • Exposure to ultraviolet radiation (principally UV-B radiation) has a number of effects on health	• Floods foster fungal growth in houses (A) • Floods foster other disease such as Outbreaks of leptospirosis — transmitted through contact with animal urine or tissue or water contaminated by infected animals — were associated with the floods in 2002 when rodents fled their flooded burrows and moved closer to human dwellings (Mezentsev et al. 2003).[23] (R / O) • A UK study found a consistent pattern of	• It is possible that indigenous malaria may be re-established in the UK by 2050. It is, however, unlikely to pose a major problem to health in the UK. Changes in the global distribution of malaria are likely and thus an increase in malaria caused by *P. falciparum* is probable in travellers returning to the UK from certain countries that are presently malaria-free.

[23] Climate change futures report Health, ecological and economic dimensions. The centre for health and global environment Harvard Medical Centre. Swiss Re and UNDP. Nov 2005.

	including sunburn, skin cancer, immune suppression and damage to the eye.[20] (R) • Increase in numbers of cataracts (A) • It has been pointed out that in addition to having a number of well-established harmful effects there may also be some health benefits from exposure to sunlight. One of the clearest beneficial effects is the production of vitamin D3 from precursors in the skin on exposure to UV-B radiation deficiencies of which can increase the risks of rickets in childhood and of osteomalacia and fractures in adults, particularly the elderly[20] (R)	increased psychological problems among flood victims in the five years following a flood (Green et al. 1985)[23] (R / O)	This particularly dangerous form of malaria is unlikely to become established in the UK in part due to conditions being unsuitable for the breeding and survival of the particular species of mosquito that acts as the vector.[20] (R) • Human contact with ticks is likely to increase as a result of changing land use for agricultural and recreational purposes. There may be an increase or decrease in the proportion of ticks infected with the *Borrelia* genotypes which cause Lyme disease. Predictions of a significant increase in tick-borne diseases, such as Lyme disease are not well founded (A)

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H = High M= Medium L = Low

Stage 4: Health adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Review building regulations for roofs and other vulnerable structures for windstorms, with adequate planning many injuries and deaths might be prevented. • Ensure standards of environmental health are kept at high level • Ensure drinking water quality standards are met		
	Research / Data collection / Monitoring	• Inventories of pollution sources • Monitoring of key pollutants and relevant weather variables. • Monitoring of food poisoning incidents • Monitoring o f pollen levels and communication to public of high levels and asthma levels • Hygiene of water monitored for increase in vermin and suitable controls undertaken • Identification of damp houses and programme of work to reduce risks	• Surveillance of diseases and outbreaks • Monitor of changing patterns of illnesses and disease to enable appropriate response • Collation and understanding of how climate change will influence changing population and knock on effect on future provision and management e.g. more elderly living to a longer age but more susceptible to heat so greater requirements for geriatric provision or greater need for ophthalmologists as increase in cataracts etc.	

	Educational / Behavioural change / Awareness raising / working in partnership	• Awareness raising of impacts of sun exposure and the dangers surrounding it. • Targeted communications campaigns to at risk groups • Education of food providers and preparers of increasing risk and standards required		
Delivering Adaptation Actions (DAA)	**Spread /Share loss**			
	Accept impacts and bear Loss			
	Prevent effects: structural / technological	• Implement building standards mechanisms to cool buildings		
	Avoid / exploit changes in risk	• Pollution warning services • Heat wave management plan developed • Emergency services to ensure sufficient capacity and training to deal with more sea / water based accidents and traffic accidents	• Need for more environmental health officers and laboratories to monitor abattoirs m food supplies etc for potential food risks • Changed work times especially for those working outdoors	• To reduce air pollution from traffic – put in place traffic restrictions, improved public transport. Incentives to promote car sharing

acclimatise commentary

Changing patterns in disease and illness will occur under climate change and need to be considered in long term planning. The impacts will not be felt uniformly across age or socio-economic groups. The more vulnerable in society are likely to be most exposed to the potential impacts. Understanding how the combination of climate change impacts on disease and health combined with the demographic and socio-economic will need to be considered in greater detail, and reviewed as our understanding of climate change improves.

The complexity of the interaction between these factors prevents means that there will be winners and losers, for example a warmer winter clearly has benefits in reducing the health risks for vulnerable groups who, for example the elderly, can face difficulties associated with the cold in winter months. By contrast during the summer, respiratory illnesses such as asthma may become an increasing problem for all age groups.

Health and social service organisations will need to monitor the impact of climate change on health and disease profiles. Adaptation responses may not necessarily take the form of direct medical treatment. Most of the work undertaken elsewhere on health impacts has focused on changes in illness and disease, vectors and vulnerable populations. Further work is required on the impacts on health care and treatment, training, building design and facilities. Additional work is also required to understand the impacts on health support services, particularly those provided by the voluntary sector.

Food preparation, hygiene and storage together with other public health issues such as contamination of shellfish through algal blooms, vermin control, drinking water quality and waste management are important issues. A warming drier summer and a warmer winter with fewer frosts creates ideal conditions for a variety of new and increasing public health impacts. Existing standards should be regularly reviewed to ensure that standards appropriate to the changing risks are set. Continuous and improved training in all areas where public health and hygiene is at risk, with a particular emphasis on the food chain and the tourism industry will be a major adaptation action.

Examples of risk

- Increased incidence of mould growth and associated health risks (asthma, allergies etc), particularly in poorly heated / ventilated housing
- Increased risk of skin cancer, heat exhaustion and dehydration
- Exposure of vulnerable groups
- Health problems associated with food preparation, hygiene and storage in higher temperatures
- Vermin population explosions

Examples of opportunities

- Tendency towards eating healthier foods in warmer weather
- Fresh healthy and locally produced food available for a longer period
- More opportunities for outdoor activities, with associated health benefits

- Reduction in fuel poverty risks for the elderly

Potential adaptation options

- Heat warning systems for the elderly during 'heatwaves'
- Awareness raising of impacts of sun exposure and the need for preventative measures, for example, Australia's 'slip, slap, slop' campaign
- Monitoring of disease and illness against changes in climate variables,, for example, temperature, humidity, and precipitation
- Assess hospital buildings and other health care facilities (existing and proposed) – design for the future not the present.
- Stress-test existing public health regulatory standards – do they provide the protection required under a warmer climate

8. Leisure and recreation

Characterisation

The Island is a long-established tourist resort and offers a wide range of facilities, which includes a theatre, cinemas, health clubs, a casino, nightclubs and top-class restaurants. The Isle of Man has a low population density with largely undeveloped moor land landscape and rugged coastline, which is very popular with devotees of outdoor sports. The choice of outdoor sport is considerable, including such activities as golf, sea and river fishing, sailing, windsurfing, hang gliding, mountain biking, diving and rambling. International car rallying, cycling and motorbike races, including the famous T.T. Races and various annual events are held on the Island. There are eight golf courses, which attract a large number of visitors to the island.

The annual End-to-End mountain bike race is gaining in popularity and in 2005 attracted approximately 400 riders from across the UK, along with TV coverage from Sky Sports channel. The Island is also famed for its bird life and there are many keen bird watchers among its visitors.

The population is small and sparsely distributed and there are not a great number of recreation facilities but the relatively new National Sports Centre in Douglas offers a wide range of sports and leisure pursuits.

An unprecedented upsurge in the growth of the retail sector, with new shopping precincts, superstores and shopping malls, has led to a transformation of the Island's shopping facilities in recent years. Heritage forms an important part of Island life in the form of museums, castles, and a rich spectrum of other ancient monuments spanning 10,000 years of Manx history.

Other than organised recreational activities there are opportunities for islanders to enjoy the many parks and green spaces that are a feature of the towns on the Island. As the population increases there will be pressure on land created by the need for new buildings and these 'casual leisure' spaces may be targeted for development.

Stage 1 and 2: Leisure and recreation

Defining the issue
Leisure and Recreation
Response

Leisure and recreation play an important role in providing good quality of life and health on the Island. It is also intrinsically linked to the tourism sector as many visitors to the Island come due to the leisure and recreation activities.

Key strategies are the Sports and Recreation Strategy, the General Leisure Strategy and National Arts Development Strategy. Some existing issues currently include:

- Use of greenways by motor vehicles and motorbikes is increasing, as is use of the same tracks by walkers, cyclists and horse riders. To resolve the potential conflicts that arise there may need to be an access management strategy/legislation.
- Erosion of footpaths and cycle paths due to heavy rainfall is an existing problem
- Bird populations on the island may be affected by climatic change during breeding and nesting seasons although this does not appear to be an issue at present
- Facilities for elderly may need to be increased as the population becomes more long-lived
- Pressures on green spaces are likely to increase
- Warmer sea temperatures may lead to greater diversity of water sports.

The problem has been identified as:

How can we reach and engage the population to improve the quality of life on the Island as well as providing essential support to the tourism sector in the face of climate change?

When considering the problem the following should be taken into consideration:

- Quality of life
- Existing erosion of footpaths and bridleways
- Pressure on Green spaces
- Facilities for all the population
- Increase in leisure / recreation users
- Land use planning
- Tourism

The problem does not directly involve managing present day climate but climate plays a large role within this sector. Adapting to climate change will need to be considered to provide sustainable decisions for the future. The main driver is not climate but it is a factor in the problem. There are already examples

of climate influencing decisions and management e.g. footpath erosion. The End-to-End course had to be changed this year due to the erosion of part of the course by heavy rainfall. Similarly the closure of footpaths has been necessitated by the same occurrence at a number of points on the Island.

Main stakeholders include recreation and leisure users, government departments, mountain bikers / race organisers / Motorcyclists, operators of existing leisure facilities, the ramblers association and other groups, bird groups, farmers and other land users

The official recorder for the British Trust for Ornithology on the island indicated that most of the birds seen on the island are well within their usual geographical range and would not be significantly affected by climate change in terms of average temperature increase unless the changes were large. He did, however, note that the populations of seed-eating birds had declined and speculated that wetter-than-normal spring nesting periods could be harmful to populations. Most species, especially those that are water-based are thriving. Also see Natural resources and environmental quality sector.

Government objective:

- To provide and promote opportunities and access for residents and visitors to participate in quality leisure, recreation, sports and the arts

Government Targets / Measured by :

- Number of patrons using leisure facilities
- % of children aged between 8 and 14 involved in extra curricular physical activity in the pilot region
- % of bus fleet accessible by disabled or less agile users
- Independent quality scheme assessment score – leisure services under QUEST®

Stage 3: Leisure and recreation impacts matrix

Climate change risks		
Leisure and Recreation	**Potential risks and opportunities**	
	Users	**Equipment / Assets**
Increasing summer temperatures (H)	• Difficult conditions for some endurance athletes regarding sunstroke, dehydration, etc. (A) • Some sports e.g. Tennis and Bowls may relish improved summer weather (A) • Potentially greater participation in outdoor sport because laying conditions would be more amenable. (A)	• Increased temperatures could have an impact on tarmac sports surfaces, e.g. tennis & netball courts, etc (A) • Increase in heath fires (A)
Increasing winter temperatures (H)	• Opportunity for all year round use or increased use of outdoor facilities (A)	
More extreme high temperatures (H)	• Impact on animal welfare (A)	• Reduction in heating requirements for indoor pool and other buildings
Less extreme low temperatures (H)	• Less disruption to events	
Higher winter rainfall (H)	• Potential increase in sporting injuries resulting from wetter surfaces (A)	• Grass pitches, wickets, bowling greens, golf courses etc. may need additional drainage systems installing (A) • Flooding could impact on the marine environment – less fish in rivers for anglers? (A)
Less summer rainfall (M)	• Potential increase in sporting injuries resulting from harder surfaces (A) • Impact on water based sports in summer months – increasing risk of pollution, low flow rivers affecting angling (A)	• Grass pitches, wickets, bowling greens, golf courses etc. may need watering systems installing (A) • Pitch maintenance would be difficult e.g. re-seeding football and rugby pitches, bowling greens and grass wickets, etc. especially with hose pipe bans (A) • Additional pitches, wickets, greens may be required so that those in poor condition could be "put to grass" for periods to recover. This would require a major capital input by Government. (A)
More intense downpours (H)	• Winter sports games, e.g. football and rugby may be "called-off" on so many occasions that their season impinges on summer sports, e.g. cricket (A)	• Sports pitches presently situated in the valleys and low areas, could be "washed" away (A) • Mountain trails for cycling and motorcycling could be eroded. (A)
Sea level rise and increased coastal flood risk (H)		• Increasing sea levels may ultimately have an impact on marinas (A) • Erosion could affect coastal land used by sports, e.g. golf courses (A)
Possibly more winter storms (L)	• Severe and increased thunder storms could be dangerous for athletes competing outdoors, e.g. golfers (A) • Severe weather preventing sportsmen and women travelling to	• Damage to club houses, facilities, etc. due to severe weather (A) • Effects on water based sports such as rowing and sailing, with clubhouse flooding from storms and rising sea levels.

	events on and off-Island (A)	Displacement of these sports in some areas could cause more pressure on environmentally sensitive areas.[24] (A / R)
General		• Timetabling of outdoor sports will be affected to avoid extremes of temperature and weather. Playing seasons for individual sports may change. (A)

Key
A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies: source = providence unclear R = Research work has been undertaken that demonstrates this impact

Confidence levels based on the UKCIP02 scenarios[9]

H = High M= Medium L = Low

[24] Sports England Response to the Stern review on the economics of climate change anticipated impact on sports facilities December 2005

Stage 4: Leisure and recreation adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Access management strategy to take into account conflicting usage of green lanes, footpaths and other rights of way etc. • Manage protected and designated areas. Integrated land use and management strategies developed	• Fire risk preparation – agree access routes for fire engineers, supplying first defences (e.g. fire beaters) (no regret)	
	Research / Data collection / Monitoring	• Monitoring damage caused by erosion		
	Educational / Behavioural change / Awareness raising / working in partnership	• Education of public to fire threat and management • Awareness raising of impacts of erosion and how to reduce the effects • Awareness / signage of tides and other dangerous bathing areas		

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Sub-soil drainage systems for both natural and artificial pitches will be adapted to store rainwater for re-use.[24] • Management plans in place for managing fires • Fire beaters to be put in place of risk	• Lifeguards on beach	
	Accept impacts and bear Loss		• Alternative grasses may be used that are more resistant to drought than those that are commonly used today[24]	• There is likely to be a move towards more all weather surfaces such as porous macadam or synthetic turf pitches, or cheaper alternatives. The shift towards all weather surfaces will significantly increase the capital and maintenance costs of a proportion of sports pitches.[24]
	Prevent effects: structural / technological		• It is anticipated that innovative, alternative-building structures may need to be developed for outdoor sports, to provide some protection from the elements. For example, many professional football clubs and local tennis clubs have already constructed low cost covered, but unheated, facilities that allow uninterrupted training and coaching throughout the year.[24] • Re-use water for outdoor watering e.g golf courses, use of rainwater harvesting.	

	Avoid / exploit changes in risk	• There may be a need to protect players, particularly children, from exposure to UV radiation, which will limit the time spent in the sun, and the programming of matches. This may lead to more sport being played under cover, either in traditional sports centres or in alternative sports structures [24] • Close areas of environment that are areas of high erosion • Close areas of environment that are high risk fire areas	• More outdoor pools that would encourage greater participation in swimming and reduce the significant running costs of indoor pools.[24] • More clay courts for tennis, as they would become more viable.[24] • Change in maintenance regimes e.g. cutting grass more frequently	

acclimatise commentary

Overall climate change impacts will be positive to the Island for leisure and recreation, although there are clearly risks for which appropriate adaptation options will need to be developed.

Warmer summers will increase the demand for water based leisure activities and new and improved facilities. The Island may well find an increasing demand for new and improved marinas. An increase in water leisure based activities also increases the risk of incidents with a consequential impact on the rescue and emergency services.

Freshwater fishing will be affected by changes in run-off and river flows and in water quality and temperature. The combination of these factors will have an impact on fish stocks and species. Sea fishing will be similarly affected by changes in sea temperature, pH and salinity.

Grounds maintenance and the design of outdoor sports pitches will need to take into account the climatic changes on plant growth and the increase in leisure and recreational activities.

The increasing attraction of summer outdoor sports will increase the risk of sunstroke and heat exposure, especially in children. Sports related injuries may also increase arising from the increased participation in recreational activities. There will be a need for greater education and awareness campaigns on such issues.

Any increase in walking will in turn increase the Island's footpath erosion problems. Recent research in the Lake District[14] has demonstrated that climate change in combination with visitor behaviour (i.e. increased numbers) will exacerbate the problem of erosion. Along with trampling, intense rainfall, combined with drought are critical factors in erosion rates. The research report comments 'footpaths are particularly vulnerable when trampling and rainfall alternate and, with walkers becoming better equipped and more prepared to go out in bad weather, this is more likely to occur.'

Adverse impacts arising from increasing leisure activity as a consequence of climate change can also result in an increased risk of moorland and forest fires. Research within the Peak District National Park has demonstrated that increases in, 'moorland wildfires in the Peak District National Park pose a significant and potentially costly environmental threat'. On the Isle of Man we can expect to see the warmer drier summers creating ideal conditions for moorland and forest fires. Footpath and access management plans will need to take into account these increased risks. Fires in remote areas away from roads and water supplies place severe stress on the emergency services.

Examples of risks

- Grass pitches, bowling greens, golf courses etc. may need additional drainage systems to cope with increased intensity and short duration storms
- Conversely these facilities may also have increased demand for irrigation during the warmer summer months
- Increased erosion on mountain trails for cycling and motorcycling, and on footpaths

- Increased exposure to the sun and an increase in sports-related injuries

Examples of opportunities

- Potentially greater participation in outdoor sport and leisure activities
- An extended 'season' for outdoor activities, and use of facilities with increases in revenues
- Reduction in heating requirements for indoor swimming pools and other leisure and recreational buildings
- Development of new facilities to meet increase in demand, creating wider economic benefits

Potential adaptation options

- Heat and sun exposure awareness raising campaigns
- Change to drought tolerant and harder wearing grass-seed mixes
- Sub-soil drainage systems for both natural and artificial pitches adapted to store rainwater for re-use
- Rain water harvesting and storage to irrigate sports pitches and golf courses
- Restrictions on access to vulnerable areas at risk from fire during heatwaves

9. Communications and energy

Characterisation

Communications

The range of options available for consumers on the Isle of Man continues to grow as the technologies develop. Manx Telecom is making substantial investment in infrastructure, whilst at the same time keeping under review its tariffs across the full range of services. Benchmarked against comparable jurisdictions, the Island must remain at the forefront of telecommunications developments. New electronic communications service providers too will be offering innovative services over both fixed and wireless infrastructure, with wider choice becoming available both to businesses and in the home.

The Isle of Man is served by both Microwave Radio and Fibre Optic Submarine Cable links to the UK. The cable has five fibre optic cables capable of carrying some 23,000 simultaneous telephone calls. A Satellite Earth Station also offers digital or analogue links to international destinations including Europe and the USA. Manx Telecom has established local call dial-up access to the Internet, which is available to anyone with a personal computer. Manx Telecom Limited is an Isle of Man registered company and a wholly owned subsidiary of British Telecom. Since Manx Telecom was created in 1987 there has been a rapid development of the Island's communications services.

Manx Radio is becoming the established public service broadcaster for the Island. New stations are bringing choice to Island listeners.

The Isle of Man Post runs the postal services on the Island. Their principle activities are the provision of a universal postal service, operation of a network of post offices and the profitable operation of selling postage stamps to collectors.

Energy

The Manx Electricity Authority (MEA) is a Statutory Board of Tynwald reporting to the Isle of Man Government through the Department of Trade and Industry. The Authority is charged by the Electricity Act 1996 with providing a safe, secure and economic supply of electricity to the Island.

Over the past few decades, substantial economic growth has been observed as an increase in on-Island demand for electricity. In 1991 the system load was 56 megawatts, whilst the forcase at that time was that by 2014 the load would increase to 82 Megawatts, in fact this load was reach by 2002.

Following a significant investment and asset procurement the Island is now linked to the UK national grid by a sub-sea interconnector. The interconnector began operations in November 2000 and is capable of carrying import or export power flows at 45MW for continuous use. A high pressure natural gas transmission pipeline is laid between the Scottish/Ireland sub-sea interconnector and Pulrose Power Station. This pipeline is controlled via pressure reduction equipment at Glen Mooar and then at Pulrose, providing natural gas to the power station and the Douglas network of Manx Gas Limited.

The Combined Cycle gas Turbin Power Station, commissioned in 2004 brought significant upgrades to Pulrose power station infrastructure, and an additional 87MW asset and can be operated on both natural gas and diesel fuel.

Location	type	year commissioned	prime mover energy	max.output
MEA				
Pulrose	CCGT	2004	gas/oil	87 MW
Peel	Diesel	1996	oil	38.4 MW
Pulrose	Diesel	1988	oil	48 MW
Ramsey	Diesel	1982	oil	4MW
Sulby	Hydro	1981	water	1 MW
Other				
UK Interconnector cable	National Grid	2000	UK mix	45 MW (upper emergency limit of 60MW/60mins)
Richmond Hill (EfW)	Waste	2003	waste	6 MW

The maximum output for each generator is dependant on certain factors, for example: the plant maintenance cycle, fuel type and ambient air temperatures.

The electricity transmission system comprises:

- the 90kV sub sea interconnector link between Blackpool and Douglas, and
- 33kV circuits which interconnect the three on-Island power stations and act as bulk feeders to the various load centres.

The distribution network operating at 11kV and LV is designed to take power from the transmission system and distribute it locally to the MEA customers in that area.

The MEA supplies 43,850 customers by a distribution network of some 900km in total of 33kV, 11kV and 3.3kV and 2167km of LV and service connections.

There are eight transmission primary substations located at Ramsey, Laxey, St Johns, Ballagawne, Lord Street, Pulrose Power Station, Douglas North and Castletown. On the distribution network there are 967 11kV substations, additional substations are installed as the load increases.

The MEA has examined the potential for the development of a wind farm on-Island in the region of 10MW, but environmental appraisal highlighted significant impact on bird populations. The Department of Trade and Industry has commissioned further investigation into the economic potential for renewable energy for the Island, this work is scheduled for completion during 2006.

The Department of Local Government and the Environment's energy from waste facility operated by SITA, takes almost all of the island's waste and generates about 6% of the island's electricity needs. This can't be improved upon without importing waste, which would be self-defeating.

Manx Gas is a multi-faceted gas utility company, working exclusively for the Isle of Man and making gas available Island-wide. It operates a one-stop 'shop' for all gas needs, from supplying and maintaining the gas, through to planning and installations, servicing support, plus the sale of new appliances. A round-the-clock safety and emergency service is provided.

Gases of widely differing constituents for many purposes are designed, manufactured, supplied and supported. These gases are used for domestic and commercial heating and cooking, leisure, and to serve the needs of industry, farming and the health services. Recently, Autogas was introduced, running motor vehicles at substantially less than the cost of petrol or diesel. Agencies cover oxygen, acetylene, nitrogen, carbon dioxide, food preservation materials and balloon gas.

A number of commercial oil operators provide fuel to the MEA, aircraft and petrol stations on Island. Strategic stocks of fuel are presently kept at Douglas and Peel.

There is a predicted population growth of up to 50% in the next 50 years, which will create a large growth in demand for energy. Based on this and projecting that growth forward it is certain that there will be the need for additional capacity, requiring the construction of additional electricity generating and transmission infrastructure and liquid fuel (petrol and diesel) storage facilities.

Stage 1 and 2: Communications and energy

Defining the issue
Communications and Energy
Response
Energy efficiency is a key issue as it has been suggested that the most significant way of reducing the climate change impact would be from the upgrading the housing and public building stock, which is largely old, draughty and un-insulated. The building stock is old and energy-inefficient. There is a projected increase in demand for the future consumption. There are no local developed energy resources - the Island has to import all of its energy needs (with the exception of that derived from waste incineration.) The safe, secure and economic supply of energy to the people of the Isle of Man is the continuing objective, covering the immediate, short, medium and long terms. All activity on the Island is based on the assumption that power will always be there whenever it is needed. For this to remain the case the MEA must plan well into the long-term. The Isle of Man Government intends to evaluate the impact of the introduction of natural gas and also carry out investigations into possible developments for future energy provision. Key concerns regarding electricity includes the risk to security of supply from insufficient generating capacity, as a result of continuing increases in demand, with the possibility of even higher increases in demand from e-commerce activities. The reliance on a single fuel supply is also considered a risk and the prospect of an increasing differential in electricity price between the Island and UK, because the only fuel was oil. With regards to the Telecommunications and Radio Services the key issues are to encourage continued fixed telecommunications infrastructure upgrade, encourage increased mast sharing by broadcasters and increasing competition. One key activity that is being undertaken is transferring cables from poles to underground ducts. The key concerns for the Postal Services include the threat from technological substitution such as e-mail and changing social needs and obligations. Therefore the issue has been defined as: **How can we provide a continuing safe, secure and economic supply of energy to meet the needs of the population and businesses in the face of climate change? How can we provide the required communication infrastructure and services to meet the needs of the population and business in the face of climate change?** When considering the problem the following should be taken into consideration: • Population • Energy usage • Security of supply • Alternative energy

- World energy costs
- Asset life
- Fluctuation in temperature has impacts for demand, efficiency, system capacity and financial implications
- Logistics of securing raw materials and supplies – impact of bad weather
- Security of supply problems with bad weather
- Seasonal variation in demand for energy
- Demand for communications (tele and broadcast) increases in extreme weather
- Impact of weather on broadcast signal strength

The problem requires adapting to future climate change. Climate change is not the main driver but will become a factor in the problem.

Key stakeholders include Manx Electricity, Manx Gas, Alternative energy suppliers, Government, Population, Businesses

Increased storm intensity and frequency could lead to enhanced erosion which would have implications for installed assets e.g. bulk storage fuel tanks. This has been recognised and protection measures were designed taking into account the 50-year projections of climate change within MEA's recent infrastructure investment. Even so there may need to be provision made for additional rock armour to prevent interruption of supply. There could be potential impacts on energy infrastructure assets due to increased wind speeds, rainfall and sea levels. Maintenance and operations could also be affected.

Climate change could become more of an issue for this sector. In particular the impact on berthing, loading and storage facilities for oil and gas has been identified.

Stage 3: Communications and energy impacts matrix

Climate change risks			
Communications and Energy	**Potential risks and opportunities**		
	Gas	**Electricity**	**Communications (telecom, postal, radio)**
Increasing summer temperatures (H)	• Out site workers and emergency services – issues pertaining to health and safety (A) • Decrease in demand – increase in costs (A) • Reduction in sales (A) • Subsidence effects could damage underground cabling, pipe networks etc. (S)	• Alfresco lifestyle affecting demand (A) • Change in demand and change in plant maintenance cycles (A) • Increased demand for electricity through air-conditioning (A) • Subsidence effects could damage underground cabling, pipe networks etc. (S) • Capabilities of equipment to transport electricity generally reduce with increased temperature. May need to invest in network improvements (S) • Ambient air temperatures effecting generator efficiency	• Protection for outdoor workforce (A) • More summer visitors – more business (A) • Increase taxation to pay for adaptation (A) • Increase in summer sickness (A)
Increasing winter temperatures (H)	• Security of supply (A) • Increase in fuel costs (A) • Reduced plant efficiency (A) • Underground movement of services (A)	• Energy cost fluctuations (A) • Increase in demand (A) • Theoretical decrease in cost (A)	
More extreme high temperatures (H)	• Less demand (A) • Equipment failure (A)	• Increase demand (A)	• Additional air-conditioning increasing need for network services (A)
Less extreme low temperatures (H)			
Higher winter rainfall (H)		• Transmission infrastructure failure (A) • Transmission and power station flooding (A) • Plant flooding (A) • Insufficient drainage pipe capacity (A)	• Peak demand during events (A)
Less summer rainfall (M)	• Damage to pipelines (A)	• Interruptions to water supply and increasing cost of supply (A) • Damage to underground cables (A)	
More intense downpours (H)		• Transmission and infrastructure failure (A)	• Peak demand during events (A)
Sea level rise and	• Interruption of gas supplies (A)	• Loss of strategic fuel storage capacity (A)	

increased coastal flood risk (H)	• Flooding of storage compounds (A)	• Impact on LPG and fuel oil supplies (A)	
Possibly more winter storms (L)	• Supply disruption (A)	• Power loss from damage to overhead cables (A) • Damage to masts, towers and equipment (S) • Interruption of oil supplies (A) • Loss of supply (A) • Continuity of supply (A)	• Loss of communications – especially broadcast (A) • No standby systems (A) • Security of service (A) • Damage to overhead cables affecting supplies for communications (A) • Increase in demand (A) • Reliability of supply (A) • Getting staff / logistics available in extreme events (A)

Key
A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies: source = providence unclear R = Research work has been undertaken that demonstrates this impact

Confidence levels based on the UKCIP02 scenarios[9]
H = High M= Medium L = Low

Stage 4: Communications and energy adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Immediate legislation to ensure all business and infrastructure issues have climate change as a key issue • Lifetime costs through planning / building regs e.g. drainage specifications (win Win) • Change building regs so that properties can withstand more extreme conditions	• Building energy conservation (Design and installation) (no Regret) • Legislation – the Climate act	• Planning / building design requirements (low regret)
	Research / Data collection / Monitoring	• Improve monitoring of rainfall and runoff	• Develop heat exchange systems • Use of tidal variations to generate tidal power • Alternative energy sources	
	Educational / Behavioural change / Awareness raising / working in partnership	• Issue sun cream to staff • Education of energy conservation • Increase awareness within all sectors of business • Energy audits of business	• Cancer awareness training • Change to working conditions – education • Working conditions – new clothing / sunscreen (share loss)	• Change of working hours (no regret) • Plant trees to provide shade (win win)

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Increase tax on property owners who live in area of risk	• Develop alternative energy sources	• Other islands are at greater risk – watch and learn
	Accept impacts and bear Loss	• Business continuity requirements (win win)	• Stockpile essential supplies (e.g. oil)	
	Prevent effects: structural / technological	• Risk assess existing assets to identify investment required (win win) • Build houses on stilts • Diversification of business by utilities (flexible) • Undertake flood risk assessments on all new builds	• All electrical systems should be put at dado rail levels • Put cables underground and not overhead • Flood proof buildings to ensure telecoms are not damaged	
	Avoid / exploit changes in risk	• Link river monitoring to all island alarm system (link flood defence and tides to same alarm)	• Sustain island's growth to afford changes e.g., creativity in business, tax and incentives. • Use solar power as reduction in cloud cover • Improve extreme weather reporting – advanced warning system	

acclimatise commentary

The energy and communications sectors both have large fixed assets that will be affected by climate change during their design life. Climate change will also have impacts upon demands (average and peak) and on security of services and supply. Asset maintenance and operating procedures will be affected by extreme events and by the changes in demand. The potential impacts and risk assessments will need to be reviewed at regular intervals as our understanding of climate change improves. All new infrastructure projects should be designed on the basis of the future climate rather than historic climate data.

Energy

Stakeholders considered that the top priority is security of supply, as the Island is reliant on off-island sources of primary energy e.g. gas, oil, coal, petrol and diesel. Energy prices are rising and consideration should be given to the possibility of fluctuations in supply from the UK. Climate change impacts have the potential to increase the potential exposure of the Isle of Man to security of supply risks. The Island may be more susceptible to changes in increased competition for available energy caused by extreme events and changing patterns in peak and average energy demands elsewhere. The Isle of Man may be left exposed by the prioritisation of energy supplies by UK and Republic of Ireland suppliers under these circumstances

Energy is likely to become more expensive in the longer term, as prices continue to rise. Prices may also rise for fossil fuel based energy sources as financial measures are taken by governments to reduce their use. Although there is clearly a significant potential impact on the Island, it also presents an opportunity for the Isle of Man to consider alternative energy sources.

Business continuity plans should address responses to issues such as disruption to supply caused by extreme events and longer term changes in demand profile, for example peak seasonal demands shifting from winter to summer.

There is an excellent opportunity to explore the development of renewal energy sources on the Island. This could provide a 'win win' situation not only providing adaptation to climate change but also allowing the Island to be more resilient to the economic impact of energy costs and contributing to the global reduction of greenhouse gas emissions. Greater self-sustainability in renewable energy sources will also assist with the development of a robust and resilient economy. The Island has an opportunity to 'choose its path' and plan for the future making greater use of renewable energy.

Future design standards, operating rules and maintenance procedures should be reviewed and stress-tested against the climate impacts.

Increasing energy efficiency has a number of potential benefits and is an important adaptation option which also has the benefit of reducing emissions. Reducing overall demand by increasing efficiency of appliances and buildings is an important action that improves the resilience of the Island.

Telecommunications

The risk of interruptions to telecommunications and radio infrastructure from extreme events is already a significant problem. The risk is likely to increase under climate change. Climate proofing of assets, maintenance regimes and design standards needs to be undertaken. The work undertaken in this study and reported in technical paper 5 has identified the significant costs associated with extreme events and the reliance by emergency services, residents and businesses on a resilient communications network.

Future design standards, operating rules and maintenance procedures should be reviewed and stress-tested against the climate impacts.

Business continuity plans should address responses to disruptions to communications caused by extreme events.

Examples of risks

- Ground movements may affect underground cabling, pipe work, overhead and underground networks etc.
- Increasing pressure on security of supply
- Disruption of energy supplies and communications during extreme events
- Change in demand profile and related changes in plant maintenance cycles
- Flooding of installed assets

Examples of opportunities

- Development of a renewable energy generation capability on the Island reducing the exposure to external security of supply issues
- Improving energy efficiency

Potential adaptation options

- Flood proof buildings to ensure assets are not damaged and services remain uninterrupted during flooding episodes
- Business continuity requirements identified, documented and periodically reviewed
- Stress- testing design, operational and maintenance procedures

10. Water management

Characterisation

Drinking water is presently provided to the Island via 10 upland impounding reservoirs, 23 service reservoirs and 5 water treatment works. Over 1200km of water mains distribute this drinking water for consumption by residents, industry and agriculture.

The commissioning of a new water treatment works at Sulby will allow the abandonment of 3 older treatment works. The new works, constructed at a cost of around £15m, went online in late 2005, and will supply clean drinking water to the north of the Island, including the towns of Ramsey and Peel.

Construction of a second new water treatment works at Douglas commenced in late 2005, as part of the Crystal Project. The predicted cost of this work is £26m, and it is programmed to be commissioned in 2008. The two remaining older treatment works will then be abandoned. Together, the two new works, with a combined capacity of 59 Ml/day, will supply the whole of the Island. They have been designed to service a population projected to 2021, taking into account the findings of the reports *"Climate Change and the Demand for Water", (P Herrington, 1996) and "Analysing and Forecasting Peak Demands on the Public Water Supply, (P Herrington, 1998)*. Aside from the increased capacity, the new water treatment works will significantly improve water quality. (Note that the climate scenarios used in these studies have been superseded by more recent climate modelling. The scenarios developed for the Isle of Man in this scoping study provide the most up-to-date information available. Future design and operational management decisions should use these earlier reports with extreme caution).

The Water Authority has a large amount of data covering rainfall and reservoir storage levels and volumes, as well as water production and distribution flows, pressures, water quality, etc. Some of the smaller impounding reservoirs are drawn down during high demand and drought periods. Operational management decisions are taken to fully utilise these resources for as long as possible.

In 1979 Tynwald subsidised the building of a reservoir at Sulby which was far larger than the Authority considered at the time that it needed or could finance for the remaining years of the 20th Century, on the basis that the surplus water thus made available would be used for hydro power generation. About 20% of the gross storage volume of the reservoir is dedicated to hydro generation, leaving a substantial surplus of raw water yield available to meet future increases in demand. The present surplus of raw water reliable yield over demand is illustrated on the graph below, see figure 2. This indicates the increase in reliable yield available to the Water Authority net of the reservoir storage volume dedicated to hydro power generation following the completion of Sulby Reservoir, and the loss in the available resource which will result from abandonment of the sources feeding the smaller treatment works which will be decommissioned following commissioning of the two new works. The drought yield available from the reservoir has been assessed based on 80% of the gross reservoir storage volume, which is available for water supply now without affecting the continued use of winter runoff into the reservoir for hydro generation. The remaining 20% of the gross storage is used as operating storage for hydro power generation. This storage volume will provide additional water supply yield to meet future increases in water demand when needed. It was always planned that hydro

generation would eventually cease once the whole reservoir volume was needed for water supply.

Current yield estimates for the reservoirs which will supply the two new water treatment works are based on a daily water resources simulation model which allows for the maintenance of at least 30 days emergency storage at the projected demand level at each individual reservoir, in addition to any "dead" storage at each reservoir. However, the reservoir yield estimates do not presently allow for the reduction in summer and autumn runoff into the reservoirs that is predicted to result from climate change.

The graph (figure 2) shows that the actual average daily volume of water put into supply has been reduced by around 5 Ml/d since the drought year of 1995, despite the significant amount of new development and the population growth which has taken place in the Isle of Man during the period. Recent water main rehabilitation works coupled with a pro-active leakage control programme have reduced leakage from 15 l/prop/day to around 6.5 l/prop/day. This is much more successful than the 10 l/prop/day that the new water treatment works were designed for, so actual demand is lower than predicted demand.

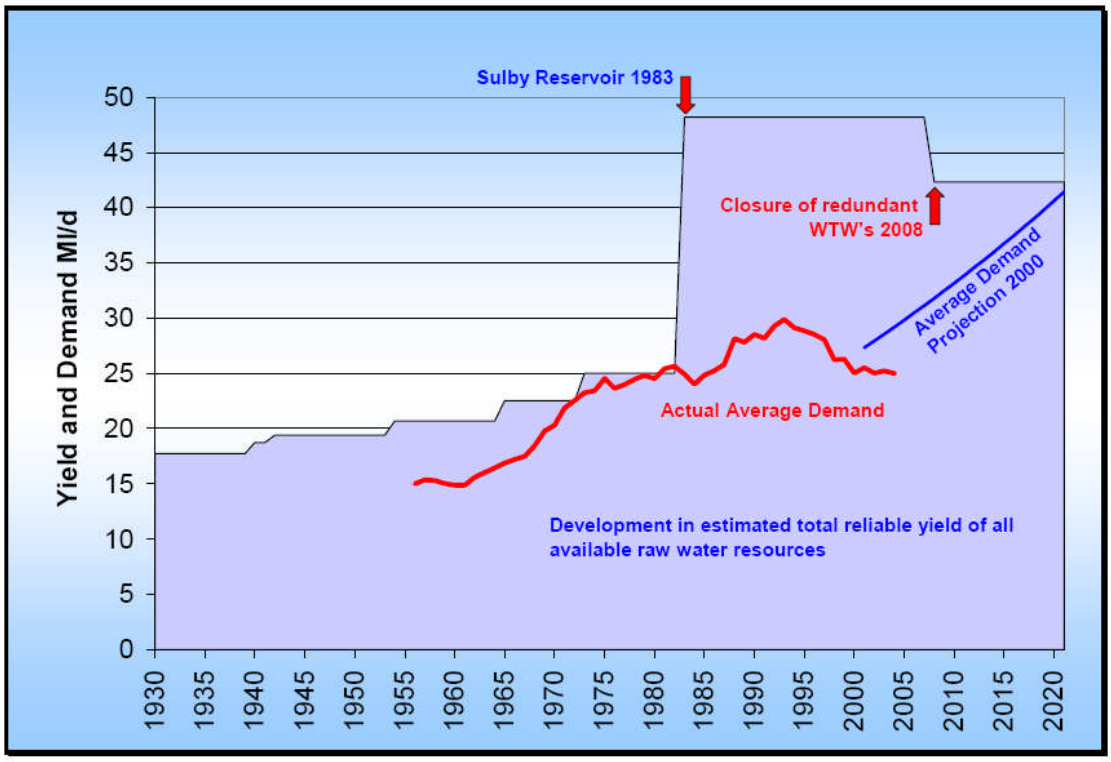

Figure 2 Raw water available and future projections of demand.

In the longer term, the graph above shows that based on current demand projections, the available surplus of resources over demand would have largely disappeared by the early 2020's, and that by that time the additional storage volume available at Sulby Reservoir which is currently dedicated to hydro power generation (about 20% of the total reservoir storage capacity), would be needed to meet demand.

All upland reservoirs, the largest of which is the Sulby reservoir, are supplied by surface water runoff. Historically, there has been no streamflow gauging on the Island, and reservoir yields were assessed using generic methods.

More recently rainfall runoff models have been developed based on a surrogate gauged UK catchment. There is now budgetary provision for constructing stream gauging stations and establishing better rain gauge coverage in the higher parts of the catchments, in order to gain robust data on the hydrology of the water sources. The first stream gauging stations are scheduled for construction during 2006/07.

Much of the raw water captured by the impounding reservoirs flows over peaty ground, which causes discolouration of the water. During some autumn periods particularly after dry summers when the ground has dried out, this discolouration can become more marked. Little, if any, of the land that forms the catchments is used for crops. This means that the risks of contamination of water with agricultural chemicals are relatively low.

Historically, all sewage on the Island was discharged to watercourses and the sea, with only rudimentary treatment or screening. The IRIS Project was conceived in the early 1990s to address this problem. So far, it has seen the construction of the Meary Veg sewage treatment works, to which around 67% of the Island's sewerage has been connected. With continued funding, it is envisaged that all of the Island's sewage will be treated at Meary Veg by 2015. However, until this time, there will continue to exist a number of small sewage treatment works that are sub-standard and that discharge poor quality effluent to watercourses.

Meary Veg has a current treatment capacity of 75,000 population equivalent (p.e.), but has the potential to be expanded to 150,000p.e. As the Island had a residential population of 76,000 at the time of the 2001 census, it can be seen that some expansion will be required before the whole Island can be served by the sewage treatment works.

The Island's sewerage system is owned and maintained by the Department of Transport, although 7 local authorities operate the sewers within their own areas through agency agreements. Much of the Island's sewerage infrastructure dates back to Victorian times, particularly in the coastal towns. Sewers are predominantly combined, although some separation has taken place as part of the IRIS project. It is believed that many of the urban sewers are operating at near capacity. As part of the IRIS work, combined sewer overflows (CSOs) are being abandoned in favour of storage solutions.

The IRIS project has been designed using hydraulic modelling tools. There are some smaller hydraulic models of the larger towns on the Island, and some drainage area studies have been carried out. However, the age and standard of these studies and models is not known.

The Department of Transport also maintains the Island's rivers. There are annual budgets devoted to both planned and reactive maintenance. The Department of Transport has an objective to prepare a strategic plan of the Island's main rivers indicating where flooding is likely to occur. A surge model of the Irish Sea is being commissioned, which will be used in conjunction with existing tidal data to create a statistical model to predict marine flooding.

There is an existing hydraulic model of the Sulby River, which was built following a significant flooding event in the late 1980s that affected a number of properties. A £1.25m flood alleviation project is proposed to reduce the chance of future flooding in this area.

There are currently no official plans indicating areas of predicted fluvial flooding. However, a study has been commissioned to undertake a strategic overview of all rivers on the Island, with a view to identifying potential areas of out-of-bank flooding.

Stage 1 and 2: Water management

Defining the issue
Water Management
Response
Water supply and sewage treatment are essential services to provide good health to the population and protection of the environment. A key programme for the Island is the Crystal Project (potable water), which includes the provision for Douglas water treatment works (2008), a raw water pipeline from West Baldwin Reservoir and treated water mains to Cronk ny Mona reservoir. It has been indicated that the sewer network is at capacity at the present time, which may become an issue in the future. The key issues raised were: • the need to be able to provide for increase in demand for potable water in warmer summers • the impact of increasing winter rainfall and storms on drainage systems • storm overflows on foul sewerage systems operating more frequently • foul flooding of property. **How can we provide the population of the Island with a wholesome, reliable and economic supply of potable water in the face of climate change?** **How can we provide the necessary treatment, distribution and sewage collection infrastructure to meet the islands needs in the face of climate change?** When considering the problem the following should be taken into consideration: ▪ Population growth ▪ Age of existing assets ▪ Asset maintenance and operation ▪ Future development ▪ Sewer network Climate is a key factor in any water and wastewater design at present and should continue to be taken into account. Climate change impacts need to be understood so that climate risks can be incorporated. Climate is an existing factor in the problem currently and will become more so in the future. Key stakeholders include the Manx Water Authority, the Department of Transport, Department of Local Government and the Environment, Manx River Trust and other NGOs, riparian owners, agricultural interests, water abstractors, recreational and leisure groups, conservation groups etc.. Existing data that is collected includes daily rainfall records, which are available for 84 years. Flood mapping research is being undertaken currently.

The IRIS scheme is also underway which aim is to provide environmental benefits by better treatment. Drainage area plans already show the capacity of the existing sewer systems and where additional loads can be accommodated. Within this surface water separation schemes are now mandatory in new developments.

Sulby flood alleviation scheme is also underway.

There are water meters for commercial properties but very few in domestic properties.

Government Objectives are:

- To ensure effective and environmentally sound treatment and disposal of foul and surface water
- To ensure the public utilities provide services that meet the Island's needs

Government Measurements:

- Water quality index score
- Percentage of the Island's sewage which is treated prior to discharge to sea

Stage 3: Water management impacts matrix

Climate change risks			
Water	**Potential Risks and Opportunities**		
	Water Supply	**Sewerage and Urban Drainage**	**Land Drainage / Coastal Defence**
Increasing summer temperatures (H)	• Resource availability (A) • Changes in demand for water • Supply versus compensation flows – impact on ecology and habitats (A) • Extraction from the south – issue of moving water and possible saline intrusion (A) • Increased demand for water in summer, domestic, agricultural, commercial and industrial use (A / S) • Public health and hygiene issues associated with reduced water supply and increased costs (S) • Greater risks of algal blooms / stratification of reservoirs (A) • Calf of Man has existing water availability problems – there are isolated affected places – not widespread (A / O)	• Anaerobic sewage on beaches for longer periods (A)	• Reduced groundwater (A) • Ground shrinkage (A) • Increased erosion on soft cliffs (A)
Increasing winter temperatures (H)	• Shorter recharge season (A) • Fewer frozen pipes (A) • Effect on water resources as temperatures increase and seasonal runoff pattern changes (A) • Increase in biological treatment – opportunity (A)	• Improved sewage treatment (A) • Less winter gritting done so less grit / salt arriving in sewage works so decrease in wear and tear on assets (A)	• Less risk of snow (A) • Maintenance regimes may require modification in order to meet required standards of service (S)
More extreme high temperatures (H)	• Increase in demand (A)		
Less extreme low temperatures (H)			
Higher winter rainfall (H)	• Quicker recharge (A) • Reservoir storage (A) • Water storage becomes a problem (S) • Oil tank structures (A) • Business continuity resilience – keep reservoirs high versus risk of flooding	• Sewer overflows operate more frequently (A) • Washout of treatment works (A) • Surcharging of sewers (A) • Increased flooding risk and flash flood in urban areas, with consequence sewer overflow (R) [25]	• Flooding (A) • Excessive runoff from land (S) south west • Proactive strategies e.g. reuse of rainwater or wastewater may be required (S) • Erosion (A)

[25] The Foresight Future Flooding Report www.foresight.gov.uk

	• Hydro plant run all year – opportunity (A)	• High rates of flow can also scour the invert of a culvert, particularly those that do not have a protective pavement.[26] (R)	• Cliff collapse (A) • Increased water table (A)
Less summer rainfall (M)	• Reduced yield (A) • Demand increases (A) • Competition with wildlife for resource (A) • Water quality reduced (A / S)	• Impact on wildlife (A) • Less flooding in summer (A) • Less dilution (A) • Increasing salinity (A)	• Reduction in ground water shrinkage (A) • Increase in erosion (A)
More intense downpours (H)	• Polluted run-off (A) • Changing flows impact on sediment transport and could increase structural damage (S)	• Sewer overflows (A) • Lack of storage (A)	• River and coastal flooding (A) • More erosion (A)
Sea level rise and increased coastal flood risk (H)		• Retaining more water (A) • Surcharging (A) • Sewer flooding (A) • Storm water / combined sewer system and surcharging – has impact on flooding, water quality, coastal and local watercourses (A)	• Flooding (A) • Potential pollution from sewage (A) • 'Dirty' water irrigation (A) • Increase in wave energy (A) • Potential for greater damage (A) • Maintenance of flood defences (A) • More destructive wave action (A)
Possibly more winter storms (L)		• Sewer flooding (A)	• River flooding (A) • Storm Damage (A)
General	• Changes in demand for water (A) • Insurance premium prices effected (floods)	• Modification of in sewer processes such as from acid corrosion and gas could be impacted on - which would necessitate changes in downstream treatment and regulation.[27] • A warmer climate may impact on vegetation growth and type which may bring both positive and negative effects for drainage systems[27]	

Key

A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies: source = providence unclear R = Research work has been undertaken that demonstrates this impact

[26] Prioritising future construction research and adapting to climate change: infrastructure (transport and utilities) by M I Wilson and M H Burtwell (TRL Limited) Project report CRISP commission

[27] Building knowledge for a changing climate. The impacts of climate change on the built environment. EPSRC and UKCIP

Stage 4: Water management adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Set up environment agency to regulate • Compensation water regulations • Planning control on development in flood plains and areas susceptible to coastal areas • Control / limit of substances into water courses e.g. agricultural products	• Catchment management for island's rivers (low regret) • Sustainable urban drainage systems (low regret) • Promote agri – environment schemes (low regret)	• Legal requirements for water meters. • Controlled retreat of coastline
	Research / Data collection / Monitoring	• Flood defence lessons from UK and other similar issues / islands • Improve monitoring of rainfall and runoff • Review capacity of sewerage and drainage infrastructure	• Identify potential flood plains – areas of risk and assets at risk	• Risk of geosmin and algae pollution of impounding reservoir. Additional treatment costs involved.
	Educational / Behavioural change / Awareness raising / working in partnership	• Shelf life is decreasing and supply chain demands are increasing. • Encourage support of local produce (no regret) • Metering to reduce water consumption • Water conservation by user education (win win)		

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Surface water separation schemes (win win) • Increasing capacity of the sewerage systems (no regret) • Increased refuse collections – to reduce health risk as temperature rises • Maintenance of existing drainage systems (Low regret) • Greater demand on recreational use of higher ground / reservoir. Increased costs of mitigating pollution risks • Ensure that adequate resources and systems are available for responses to climate related emergency events e.g. flooding; • Reduction in leakage • Water metering • Promotion of water efficient appliances • Rainwater harvesting promoted • Water saving measures implemented (win win)	• More reservoirs for storage (no regret) • Development of innovative water resources options	
	Accept impacts and bear Loss	• Identify all houses in flood plains – buy and demolish • Water butts for garden use (win win)	• Pulrose power station - risk of flooding. 1953 flood removed bridge • Desalination plant • Water restrictions on non essential use in times of water shortage	
	Prevent effects: structural / technological	• Flood defences, structural recommendations on all new developments to reflect flood alleviation risks • Better drainage systems, particularly along highways and railways. • The use of low maintenance vegetation to act as buffer zones, whilst not hindering the growth of other vegetation • Increase infiltration into land, design of urban areas. • Promotion of flood proofing on buildings at increased risk from flooding; • use/re-creation of natural eco-system buffers • Use of sustainable urban drainage systems (SUDS)	• Increase in storage capacity • Design limits for drainage systems will require reappraisal	• On landslips • Use of green/open spaces for temporary water storage to alleviate flooding.

	Avoid / exploit changes in risk	• Avoidance of developments in at risk areas or making sure that adequate protection is in place	• Increase use of sewage in agricultural irrigation • Management of water resources and low flow rivers to manage reduced water quality • Potential for greater use of greywater and rainwater harvesting	• Look at insurance premiums by reviewing pricing policy, restriction on buildings • Management of abstraction licences for water supply

acclimatise commentary

There will be a significant climate change impact on the water environment. The direct effects will be felt on water resources, the treatment and supply of drinking water, sewerage and sewage treatment and drainage. There will also be significant indirect effects on all those other sectors where the water environment is an integral element, for example, agriculture, tourism, the built environment, business, and the ecology of the Isle of Man.

Baseline data collection is extremely important. It is recognised that there are knowledge gaps (for example, accurate catchment models and watercourse flow monitoring) and steps are being taken to address some of the issues. A regular periodic review of the impacts of climate change on the water environment and on the demands for water from competing sectors is required, together with a programme of stress-testing assets. Design standards, operational procedures and maintenance regimes will have to change in response to the anticipated and actual changes in the climate.

Water resources

Climate change will affect the reliable yield and quality from reservoir and stream intake sources. The Water Authority acknowledges that the reservoir yield estimates do not presently allow for the reduction in summer and autumn runoff into the reservoirs which is predicted to result from climate change.

There will be increasing competition for the water resources, for example to maintain minimum flows in watercourses and from agriculture for irrigation.

The work undertaken in this study on the hydrological impacts of climate change (see technical paper 10) emphasises the need for routine flow monitoring in watercourses to build a better understanding of each of the catchments. Gauging stations will provide baseline data required to assess in detail the hydrological impacts of climate change from both a resource and flood management perspective. This will allow more robust and resilient adaptation options to be assessed.

Water treatment and supply

The impact of climate change was considered during the design stage of the two new treatment works. Although the best available information was used at that time they have been designed to service a population projected to 2021, taking into account the findings of reports published in 1996 and 1998. These reports reflected the state of understanding of climate change from the early 1990s. It should be noted that there have been significant advances in our understanding of the climate change in the last 15 years. It is recommended that the designs should be stress tested against the climate scenarios presented in this report, and against the more recent guidance provided by the Environment Agency in England and Wales and the UKCIP CCDew report.

Raw water quality will be affected by climate change resulting for example from changes in water temperature, the breakdown of moorland soils leading to increased tannin levels causing discolouration and nutrient discharges from agricultural land. Water quality will also be affected in all watercourses by the impact of storm run-off during low-flow conditions. The potential increase in use of fertilisers if land at higher altitude is brought

into agricultural may need to be controlled. The treatment processes at the water treatment works will need to be able to cope with a changing and perhaps more variable raw water quality over their asset life.

Hotter summers and warmer winters will create additional problems for the maintenance of water quality in supply and distribution systems. Monitoring procedures and operational practices will have to be regularly reviewed to ensure that drinking water quality at the tap does not deteriorate.

The demand for drinking water will be affected by the direct and indirect climate change impacts identified in this report. There will be increasing competition for water between agriculture, leisure, business and the environment. Extended dry and warmer periods during the summer may become an increasing problem. Demand management, water conservation, water efficient appliances, leakage control and drought contingency plans all have a role to play as adaptation measures. Additional measures such as water harvesting, use of grey water and water efficient designs for new buildings can be effective as a demand management option.

Sewerage and sewage treatment

A change in rainfall patterns (short duration, high intensity storms) will place pressure on sewerage systems, leading to increases in storm and foul flooding in urban areas, and pollution of watercourses. Sewer and pumping station design standards will need to be reviewed to take into account the change in rainfall patterns and storm return periods.

.There will be an increasing risk of pollution in low flow rivers during summer months from storm overflows and surface water drainage systems. Storm overflows will operate more frequently. Drier summers will encourage the build up of silt, fats and other material, and intrusion of tree roots, leading to an increased risk of blockages and both surface and foul flooding. Vermin control in sewerage systems during the summer and over an extended period with warmer winters will become an increasing problem. Higher temperatures combined with drier periods in the summer will increase the risk of septicity in sewerage systems leading to significant odour problems.

The operation and management of sewage treatment processes may be affected by the change in rainfall patterns and by increases in both water and ambient air temperature. Odour and fly nuisance may increase and require remedial treatment measures.

Discharge conditions for the discharge of treated effluent, surface water drainage, storm overflows, and trade effluents will need to reflect the impacts of climate change on the receiving watercourse. Tighter consent standards may require additional or new treatment measures to be introduced.

Drainage and flood management

All the climate change scenarios predict an increasing risk of flooding both from rivers and watercourses. Baseline data needs to be collected to add to the understanding of the current risks, to enable flood maps and event return curves to be created. Following on from this comprehensive modelling on flow characteristics and runoff of the watercourses across the island needs to be undertaken. This is also an important issue for strategic and emergency planning, land-use planning, the design, location and maintenance of property

assets and infrastructure. The costings work (see technical papers 5 and 7) has demonstrated the significant costs associated with extreme events and the importance of climate proofing.

Coastal areas are under an increasing risk from flooding. There is a need to review defence systems to ensure they are fit to withstand the impacts of climate change on sea level rise, storm surge, wave height and tidal patterns. These impacts will also change existing erosion and deposition patterns along the coastline leading to new and increasing erosion risks and flooding. It is also important that development proposals take into account the increasing risk of coastal flooding and factor this into their design. The proposed scheme for the redevelopment of the Douglas Promenade should for example be designed to take into account a range of climate scenarios.

The changes in precipitation and storm events will also affect the extent of flood plains and the frequency of their inundation. Land-use planning has an important role to play in assessing the risks for new development, ensuring the sustainability of future development and that the risks to existing property do not increase.

A comprehensive drainage and flood management strategy is required to understand the existing risks and the impacts of climate change. Sustainable urban drainage systems have an important role to play. However whilst they can significantly reduce the risk of flooding in new developments, they are less effective (and may be entirely inappropriate) for existing urban areas.

Examples of risk

- Increased risk of algal blooms and stratification in reservoirs
- Increased river and coastal flooding risks, and flash floods in urban areas
- Increased frequency in operation of storm overflows leading to watercourse pollution
- Drinking water bacterial failures arising from increases in water temperature
- Water treatment processes unable to cope with changes in raw water quality
- Increased competition for limited raw and treated water resources

Examples of opportunities

- Increased ambient air and water temperatures may improve sewage treatment biological processes
- Potential for reuse of rainwater / rainwater harvesting
- Adopting a cross-sectoral approach to both flood management and water resources

Potential adaptation options

- Stress testing of water and sewerage assets, to assess their resilience to climate change
- Encourage water conservation and demand
- Incorporate climate change into all designs for flood defences – design for the future and not on historic data.

- Review sewerage design standards and encourage the use of SUDS for new development proposals
- Use open spaces, parks, recreational areas for temporary water storage to alleviate flooding.
- Baseline data collection on catchments, flows, flood plains and event return periods.

11.0 Waste management

Characterisation

Waste management on the Isle of Man has been radically transformed by the construction of a waste-to-energy plant, comprising two incinerators, a 60,000 tonnes per annum (tpa) primary incinerator and a 5,000 tpa secondary incinerator for special wastes. The plant accepts nearly all of the Island's waste.

The Island's first waste management plan was published in November 2000. It is due for review and a consultation document has been issued, which identifies five key issues facing the Island in terms of waste management. The further implementation of the Island's Waste Management Strategy is also seen as a key challenge because, whilst considerable progress has been made in recent years, there is still a requirement for two new Civic Amenity Sites; "green" and problematic waste facilities; and long-term landfill for residual wastes.

The government remains committed to the "user pays" principle and to securing a better understanding by the community of the true cost of dealing with the various types of waste. In 2004/05 the cost was in the region of £10.7m or £143 per person per annum.

Charges for waste disposal provide both an incentive to encourage greater waste minimisation and recycling and a means to recover at least a proportion of the unavoidable costs of disposing of waste. Around 50,000 tonnes of waste are being incinerated at present and over 30,000 tonnes land filled per annum though this latter figure is reducing steadily.

Stage 1 and 2: Waste management

Defining the issue
Waste Management
Response
The waste strategy is currently being reviewed and there are various issues that have been raised in relation to waste management. The cost of waste disposal and the charging structure together with responsibilities for waste was identified as needing to be addressed. Disposal methods such as recycling, incineration and landfill have to be examined to identify the sustainable options. Discussions indicated that cost benefit analysis should be used in decisions and that attitudes towards waste management needed to change. Waste management is a contentious subject on the Island but one that needs to be addressed and a solution found. The decision has already has been made to follow the incineration route but this needs to be supported by other waste reduction initiatives and other waste disposal options e.g. composting. Other key concerns included the Island's waste capacity for the future and the impact of waste disposal options on the landscape and the risk of pollution from existing and old sites. Other sectors which impact on waste included tourism in the peak season that creates waste management capacity problems and agricultural practices which impact on the environment. The problem has been identified as: **How can we dispose of the Island's waste in a safe and efficient way in the face of climate change?** When considering the problem the following should be taken into consideration: ▪ Cost of waste disposal ▪ Recycling ▪ Education and communication The problem does not involve present day climate but it may involve adapting to climate change. Although he main driver is not climate change it was considered that climate change would become more of an issue, as higher temperatures will create problems for collection rates and separation of waste. Stakeholders include Zero Waste Mann, DLGE, waste processing operations, the general public, business, consumers. Climate change may have an impact on the movement of ground water so this may affect any existing or proposed landfills. The waste from energy plant and any future development need to be assessed for climate risks.

Stage 3: Waste management impact matrix

Climate change risks		
Waste	**Potential risks and opportunities**	
	Waste management	**Contaminated land**
Increasing summer temperatures (H)	• Smell (A) • Increasing costs (A) • Health (A) • Vermin (A) • Higher rates of decay in waste (A) • Increased health risks to workers from increased sunshine and exposure to UV radiation and increased pathogen and vermin activity[29] (A) • Increased site disagreeability from odour, vermin, dust and litter[29] (A) • Increase the rate of waste decomposition within waste reception and storage bunkers, leading to higher levels of odour, dust, insect infestation and bioaerosols[29] (A) • Give rise to situations where this is a greater risks of diseases being transmitted where putridly waste is handled[29] (A) • Impact on the selection of waste collection containers if adverse impacts are to be avoided (A) • Need for recycling of washing water (A) • Decay of green waste to be utilised (A) • Increased volume of cans and bottles (A)	• Increase in the mobility of contaminants in the ground caused by the changes in soil behaviour due to drying out and/or changing groundwater levels. [28] (R) • Increasing ground temperatures could lead to soil desiccation and upward capillary suction of polluted water, exposing the contaminant at the ground surface.[28] (R) • The mobility/volatility of certain organic compounds could be increased, causing extended pollutant movement in the ground.[28] (R)
Increasing winter temperatures (H)	• Vermin (A) • Increase in green waste – extended growing season (A) • Change in types and distribution to vermin and pests[29] (A) • Increase in composting rates [29] (A)	
More extreme high temperatures (H)	• Smell (A) • Collection disruption (A) • Increase costs (A)	
Less extreme low temperatures (H)	• Influencing the types and amount of flora and fauna on and around facilities and the choice of ecological communities used to restore landfill sites[29] (A)	

[28] Impact on climate change on pollutant linkage. Project brief. http://www.subrim.org.uk/contact/workpackages/wpi/wpi.htm

Higher winter rainfall (H)	• Increased run off causes pollution events (A) • Increased disruption to supporting infrastructure e.g. road from increased flooding from surface water, groundwater and drainage systems. This could also affect some on site facilities e.g. weighbridges and gas and leachate collection systems[29] • Increased leachate production in the winter months[29] (A) • Impact on the combustion process if waste is of higher moisture content than anticipated. This may result in variations to chemical and reagent usage in the flue gas treatment systems[29] (A)	• Costs of remediation (A) • Leaching increases (A) • Restoration and use of landfill (A) • Future design (A) • Higher intensity rainfall would almost certainly increase rates of erosion and may also increase the spread of ground contaminants[28] (R) • Impact of changing rainfall patterns on contaminated land – increase risk of pollution
Less summer rainfall (M)	• Reduce water availability for site management e.g. dust suppression[29] (A)	• Increasing risk of contamination of drinking water (A)
More intense downpours (H)	• Increased disruption to transport infrastructure due to flooding and hence delivery of waste[29] (A)	
Sea level rise and increased coastal flood risk (H)	• Inundation and /or erosion of low lying coastal facilities[29] (A)	• Risk of contamination from oil spillage (A) • Impact of sea level rise on oil storage facilities and contaminated land (A)
Possibly more winter storms (L)	• Backwash of sewers (A) • Disruption of collection (A) • Litter and paper blowing around (A) • Structural impacts on tall buildings / structures e.g. incinerator (A) • Increased damage to site buildings from storm (A)	
General	• Changes in site hydrology and temperatures which in turn could affect waste management processes e.g. landfill degradation rates, leachate production and composition[29] (A) • Increased risk of subsidence and slope instability from drying out of soils followed by rapid wetting due to heavy rainfall[30] (R) • Reduce dispersal of stack emissions (A)	

Key

A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies: source = providence unclear R = Research work has been undertaken that demonstrates this impact

[29] Potential impacts of climate change on waste management. Jonathan Bebb, Jim Kersey. Entec UK. Environment Agency 2003

[30] Jones D.K.C. 1993. Slope stability in a warmer Britiain. Geographical Journal, 159, 184-195. Quoted within Climate Change Impacts on Waste Management. Environment Agency 2003. J.Bodden and J. Kersey.

Stage 4: Waste adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Single Island authority for waste management with uniform standards. • Increased segregation of waste at source.		
	Research / Data collection / Monitoring	• Carry out a high level risk assessment to identify those sites and processes that could be most affected by climate change and formulate appropriate action plans to address the potential impacts[29]	• Identification of contaminated land; pathway and receptors	
	Educational / Behavioural change / Awareness raising / working in partnership	• Education needed on waste separation and segregation (no regret) • Continue to build a shared understanding of the potential impacts of climate change on waste management policy and practices • Education on incineration and recycling		• Changing waste profile e.g. more green waste and increased rate of frequency of collection
Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Increased refuse collections – to reduce health risk as temperature rises • Greater demand on recreational use of higher ground / reservoir. Increased costs of mitigating pollution risks		• More frequent rates of collection
	Accept impacts and bear Loss		• Waste management operations to be performed under cover	• Old landfill sites – pollution, leachate, erosion
	Prevent effects: structural / technological		• Greater use of odour and bio-aerosol control measures • Design waste collection containers to keep waste dry	
	Avoid / exploit changes in risk			

acclimatise commentary

There has been comparatively little research undertaken to date on the impact of climate change on waste management. The impacts and adaptation options that have been identified are mainly based on anecdotal evidence.

The Island has many challenges surrounding waste management as it examines the most appropriate sustainable strategy for the management, treatment and collection of waste. The waste management strategy for the Island is currently being reviewed and it should be stress-tested with the climate change scenarios. Climate change needs to be integrated into this decision making process as it may influence the options for the future.

The impact on climate change on other sectors, for example tourism, will have knock-on impacts for waste management. Sustainable cross sector solutions will need to be considered. The potential public health issues arising from a warmer climate for pest and vermin control, odour management and disease with regard to waste management should be carefully assessed. Adaptation options may need to be considered involving increasing the rates of collection or different refuse storage options.

Examples of risk

- Increased rate of waste decomposition within waste reception and storage facilities leading to higher levels of odour, vermin and insect infestations.
- Impact on the combustion process if waste is of higher moisture content than anticipated. This may result in variations to chemical and reagent usage in flue gas treatment systems[29]
- Higher intensity rainfall would almost certainly increase rates of erosion and may also increase the spread of ground contaminants on landfill sites.

Potential adaptation options

- Increased refuse collections – to reduce health risks as temperatures increase.
- Design waste collection containers to keep waste dry.
- Education needed on waste separation and segregation.

12. Built environment

Characterisation

At the time of the 2001 census, there were around 31,500 houses on the Island. Based on the predicted growth rate of the population, and the reduction in average household size, the Department of local government and the environment (DLGE) has established a policy to make provision for 5,400 additional dwellings in the period 2001–2016.

The Island has been subjected to a sustained period of economic growth that has resulted in a steady inward flow of people moving to new jobs and requiring housing. The Island's house building programme has not been large enough over recent years to supply sufficient properties to meet the increased demand, caused partly by changes in social trends, such as decreasing household sizes.

Historic buildings are seen as an asset to the Island, and to the quality of life enjoyed by its inhabitants. A list of Conservation Areas and Registered Buildings has been drawn up, which identifies areas and buildings of particular architectural, social or historical interest. Environmental policies have been written to offer protection against any development that would detrimentally affect the specific character of Registered Buildings. Climate impacts on historic buildings are discussed in the historic environment section.

Protecting and improving the quality of the natural and built environment of the Island makes it important that there should be effective systems of Strategic Planning and Development Control, coupled with appropriate conservation measures.

The introduction of the remaining parts of the Town & Country Planning Act 1999, and work towards putting in place four new Area Plans for the Island, with extensive public consultation on each one, will ensure that the Island has a comprehensive Development Plan in place by 2010. The current Development Plan comprises the Isle of Man Planning Scheme (Development Plan) Order 1982 and 13 Local Plans covering individual towns and villages. Though securing full Area Plans' coverage for the Island could take well over a decade (with current resources), work on the Plan for the South will begin in 2005/06 during which the timetable will be put in place for bringing forward draft Plans for the West, North and East of the Island.

Four regeneration areas have been identified in the *Island Spatial Strategy*. These areas are located in Douglas, Peel, Ramsey and Jurby. Developments will be spread throughout the Island in line with this Strategy, and will be sited within, or form sustainable extensions to, existing towns and villages.

The mismatch of housing supply and demand, coupled with low interest rates, has overheated the housing market and resulted in a rapid rise in house prices. The average price of a home is now £200,000, which is twice the cost of what might be affordable for a typical first time-buyer on an annual income of £20,000 to £30,000. These factors have created a backlog of demand for single units and for affordable housing from the indigenous population and some new arrivals. There is also a growing demand for specialist retirement housing.

The Government has earmarked funding to increase the supply of housing but there are difficulties in securing sufficient zoned land to meet housing targets. The programme for bringing forward the Area Plans and the proposal in the draft All-Island Strategic Plan to ensure new planning permissions provide 25% affordable housing should help in the medium to longer term.

Stage 1 and 2: Built environment

Defining the issue
Built Environment
Response

In the discussions on the built environment a number of cross-sectoral issues were identified.

The Island's Strategic Plan is currently under modification - within this there is a provision for 5,400 new houses between 2001 and 2016.

The key issues that were highlighted included:

- Storm water management of roads
- Harbours, sufficient breakwater, quayside height, storm surge height
- Traffic congestion and road pollution, need to upgrade train to metro but still able to take trains
- Quality of housing, dampness, housing conditions, flood proofing
- Alternative energy
- Coastal protection of built environment.
- Access to minerals at coastal sites, rising sea level
- Energy efficiency of new buildings and old stock
- Location of new development

The problem has been identified as :

How can we provide affordable and robust development in the face of climate change?

When considering the problem the following should be taken into consideration:

- Development control process
- Future development
- Climate resilient buildings
- Flooding

Climate is already a factor - dampness is a problem in existing properties.

Building regulations follow what is happening in the UK (usually a minimum of 2 years behind).

Concerns that drainage capacity in urban areas is already limited. The Department of Transport has an objective to prepare plans of the Island's main

rivers indicating where flooding is likely to occur.

In certain areas climate is already effecting decisions as overhead wires are being put underground. The driver for this was damage from storms.

Stakeholders include developers, owners of existing at-risk properties, all Government Departments.

Activities ongoing on the Island

- Separation of storm drainage required on new buildings
- Review of building regulations.
- Planning more friendly on solar and wind energy applications
- River and coastal monitoring / understanding projects.
- Attitudes towards insurance cover by insurance companies in areas at risk from flooding.
- Subsidence is also a problem in some places

Stage 3: Built environment impact matrix

Climate change impacts			
Built Environment	**Potential Risks and Opportunities**		
	Design / Construction	**Maintenance of existing property**	**Land use planning**
Increasing summer temperatures (H)	• Road coating products- tarmac melts (A) • Increase cost of new build and upgrade of existing (A) • Better insulation (A) • Overheating in existing and new buildings (S) • Increased requirement for specialist expertise in technical aspects such as cooling, ventilation, passive solar design (S) • Increased solar gain for passive water heating, photovoltaic etc (S) • Prospect of new internal finishes (e.g. ceramic floor tiles in place of fitted carpets) (S) • Possible increase in demand for canopy type structures externally (S)	• Increased maintenance of road surfaces (A) • Building fabric exposed to thermal stress (S) • Drying of substrate, leading to increased subsidence (S)	• Urban design changes – impacts on street scene and landscape • Building design changes challenge traditional IoM characterisation.
Increasing winter temperatures (H)	• Increase drain sizes for developments and roads (A) • Less need for insulation (A) • Less requirement for space heating (S) • Less days lost through frost on construction sites (S)	• Lawns and other amenity planting likely to require more maintenance (S) • Potential for reduction in winter maintenance costs[31]	
More extreme high temperatures (H)	• Increase in building cooling costs (A) • Design build to include comfort cooling (A)		
Less extreme low temperatures (H)			
Higher winter rainfall (H)	• Water course design and upgrades (A) • Road drains need to be larger (A) • New developments need storm water management (A) • Some worsening of construction site conditions e.g. concrete, mortar etc (S) • More robust designs required for rainwater disposal systems above and below ground (S) • Higher specifications required for new drainage systems (especially urban) (S) • Opportunity for introducing SUDs in new developments (S) • Rising costs of construction due to delays[32]	• Increased need for maintenance of drainage ditches (A) • Risk of flooding to property (A), both from fluvial, coastal and sewerage which may lead to structural collapse • Change to design criteria for road beds (A)	• Covered shopping areas (A) • No building in flood plains (A)

[31] Prioritising future construction research and adapting to climate change: infrastructure (transport and utilties) by M I Wilson and M H Burtwell (TRL Limited) Project report CRISP commission

[32] Adapting to climate change: A checklist for developments. Guidance on designing development in a changing climate. Southeast Climate Change Partnership, SDRT for East of England

	• Increasing dampness leading to mould • Health problems associated with dampness • Increased risk of landslips • Increased incidence of road accidents[31]		
Less summer rainfall (M)	• Water supply problems during construction and during building's use (S)		• Water use management (A)
More intense downpours (H)	• Drains and contamination health risk (A) • Increase drain size for roads due to increased rainfall (A)	• Risk of flooding (A) • Extension of separation of storm/foul (A) drainage into separate systems to cope with increased flows (A)	
Sea level rise and increased coastal flood risk (H)	• Restrictions on location of proposed developments (S) • Requirements for flood defences to protect existing buildings (S)	• Increased risk of flooding (A) (S) • Low lying and harbour side properties at risk (A)	• Avoid low lying coastal locations (A) • Political influence (A) • Harbour and quays (A)
Possibly more winter storms (L)	• Need for more storm resistant designs (A) • Wave attenuation features offshore from harbours (A) • Structures and roofs vulnerable to damage in exposed locations (S) • Buildings and infrastructure under construction vulnerable to extreme events, especially in exposed locations (S) • Higher wind speeds will increase the loading on signs and gantries, thus the structural detail of the panels and fixings might have to be reviewed in the light of climate change (R)[31]	• Manton Road Douglas open instead of closing when snow (A) • Risk of damage to existing structures (A) • Larger harbour walls and armouring (A) • Walls and windows, especially cavity filled walls vulnerable to driving rain penetration, especially in exposed locations (S) • Increasing weathering of building facades (A)	
General / Indirect effects?	• Litigation risks for consultants and contractors, associated with both designs and existing buildings (S)	• Increasing insurance premiums to non-climate proofed buildings[32] • Climate change will affect the durability of materials (A)	• If tree planting changes due to need to provide more shades etc then it may affect building foundations e.g. species with too high a water demand will cause subsidence (S)

Key
A = Accepted wisdom / Anecdotal evidence O = Observed, the impact has already been seen S = Information obtained from other scoping studies: source = providence unclear R = Research work has been undertaken that demonstrates this impact

Confidence levels based on the UKCIP02 scenarios[9]
H = High M= Medium L = Low

and London Climate Change Partnership November 2005

Stage 4: Built environment adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Introduce new design standards for drainage for new development • Energy efficiency of new buildings – need to insulate for winter but keep cooler in summer • Flood proofing of housing. • Do not allow house building in likely flood areas / coastal erosion • Revise plans sooner to prevent building on flood plains • Review Island Strategic Plan to take into account the effect of climate change (No Regret) • Regulation and inspection must take place in building trade to ensure energy efficient methods used • Creation of an 'environment agency' to ensure new legislation is carried out properly with proper inspectors methods and if necessary prosecution • Redirect resources from planning / visual impact to planning design / building control • Good maintenance and workmanship assists in reducing rain and damp conditions.	• Offer grants to improve energy efficiency in existing old houses	
	Research / Data collection / Monitoring	• Restrict location of new development • Understand situation of dampness, housing conditions and whether they need 'flood proofing' • Identify those roads that are most prone to flood damage (historical data) and produce action plan (no Regret) • Need more information on rivers and flows • Keep existing places of research open and running to monitor on going changes in the environment (no regret) • Understand life cycle aspects of building materials, design and demolition, use and location.		

	Educational / Behavioural change / Awareness raising / working in partnership	• Education and behavioural changes is thought most important by group • Audit business, households and ministry to reduce energy use • Campaigns now to educate people in how their lifestyles contribute to decreasing climate change (low cost) • Educate children, adults and make information on risky areas widely available		

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• More recycling of building materials • Weir and reservoir to better manage water flow and retain more water for better management of supply. • Coastal protection of built environment • Higher insulation levels to protect buildings from increased temperatures and reduce energy use in winter • Increase stability of telegraph poles, pylons and other structures prone to wind loading[31] • Strengthening of roofs and claddings on existing buildings[31]	• Ensure major items of infrastructure are protected against storm / flooding damage. • Use of more durable materials such as more corrosion resistant metals[31]	
	Accept impacts and bear Loss			• Stop development in coastal erosion zones • Let nature take it course in coastal zones
	Prevent effects: structural / technological	• New harbour / coastal structures to take account of sea level rise and increased storms • Change drainage design standards to allow for future demand (Low regret) • Storm water separation from foul sewerage system • Reduce building densities • Changing building height, spacing and street orientation to increase shade and reduce isolation receipt • Passive designs of buildings to be implemented e.g. shading from the sun. Making provision for controllable ventilation during the day and high levels of ventilation at night (without compromising building security). Using heavier weight building materials combined with night ventilation, to enable heat to be absorbed and released into the building fabric; improving insulation and air circulation (e.g. cutting down on draughts) which enables undesirable heat flows to be controlled.[33]	• Improve maintenance of infrastructure to deal with climate change e.g. improve capacity of rivers / drainage systems by cleaning • In commercial buildings have greater emphasise on design for 'cooling' systems • To adapt to floods raise floor levels, safe access requirements, land raising, flood warning systems, flood proofing, flood defences, provide compensatory flood storage. SUDS and pumping. Options vary on development / area etc.[34] • Raising the level of marina and harbour installations	

[33] JN, Belcher, SE & Connell, RK (2005). Beating the Heat: keeping UK buildings cool in a warming climate. UKCIP Briefing Report. UKCIP, Oxford.

[34] A toolkit for delivering water management climate change adaptation through the planning system prepared for the environment agency and SEERA by Land Use Consultants. South East England Regional assembly, Environment Agency and ESPACE March 2005

	Avoid / exploit changes in risk	• Build in climate change now into design for structures e.g. harbours, sufficient breakwater, quayside height, storm surge height • Enhance natural ventilation through variation of building height and density • Achieve effective solar shading using trees and vegetation • Use of high albedo (reflective) building materials • Incorporation of large areas of vegetation and water features within urban landscape to encourage cooling airflows • Provision within developments of spaces for outdoor activities e.g. shared areas for BBQs and entertainment • Use the ground floor space for flood compatible uses e.g. car parking or raise the ground floor above the likely flood level[32] • Increase use of wind power for generating electricity	• More outdoor swimming pools • Solar and wind power maybe viable • Changes for agricultural crop rotation and farming methods	• Use Sulby reservoirs pumped storage for instant power availability for peak loads and emergency electric supply

acclimatise commentary

The built environment is one of the most susceptible sectors to the impacts of climate change. The buildings, assets and infrastructure, their design and layout, their function and form were all based on a traditionally stable climate. Adaptability in both form and function to a changing climate and to changes in the needs of society is an important issue for the Isle of Man.

Increasing temperatures will affect the maintenance, operations and usability of buildings. Temperature increases will mean that buildings may become too hot, limiting their usefulness and function. The introduction of air conditioning will increase energy usage, adding to emissions. Passive cooling mechanisms need to be investigated for both existing and new buildings.

Climate is already a factor in existing building design with dampness a major problem in older properties. Under the climate change scenarios in warmer wetter winters this problem may increase. Adaptation options will have to be considered to reduce this impact and the associated health problems.

Some parts of the Island would be particularly sensitive to a rise in sea levels, e.g. Ramsey and Douglas. This may require existing buildings to be protected or relocated. It will also influence the location of future developments.

The hydrological impacts (see technical paper 10) will affect the extent of flood plains and the frequency and intensity of flooding. Flood mapping for land use planning should be based on return period events using the climate change scenarios, rather than events drawn from historic climate data.

Changes in precipitation will have an impact on urban drainage systems. Baseline data collection is required to understand the current situation so forward looking projections can take climate change into account.

The economic impact of floods both coastal and riverine should be considered in development and any defences that are required. As demonstrated by the future costing work of extreme events flooding can be very costly and a balance needs to be struck between the siting of development and the economic implications of flooding. Insurance coverage has already been identified as an issue and will play an increasing role in determining the economic viability of development.

Examples of risk

- Overheating in existing and new buildings
- Increased requirement for specialist expertise in technical aspects such as cooling, ventilation, passive solar design
- More robust designs required for rainwater disposal systems above and below ground
- Increasing dampness leading to mould
- Increased risk of coastal and river flooding and sewer flooding
- Increased risk of subsidence

Examples of opportunities

- Increased solar gain for passive water heating, photovoltaic etc
- Less days lost through frost on construction sites

Potential adaptation options

- Strengthening of roofs and claddings on existing buildings
- Use the ground floor space for flood compatible uses e.g. car parking or raise the ground floor above the likely flood level
- Restrict location of new development

13. Natural resources and environmental quality

Characterisation

Air The government's monitoring stations demonstrate that the air quality on the Isle of Man is generally good but that there are regularly levels of Ozone and PM10 particulates in excess of the objective concentrations. Both of these effects are the result of oxidation of nitrogen and sulphur oxides. The control of concentrations on the Island is probably outside the control of the Manx population. In common with the rest of the world there is increased car ownership on the Island and this, coupled with increased population might conceivably lead to localised pollution due to exhaust fumes.

Water There is pollution of watercourses stemming from Victorian mining activities, which has a significant impact on aquatic biological resources and fisheries. There are no plans to remediate this source of pollution, as it is too diffuse and costly to deal with. A significant increase in the concentration of aluminium was recorded in association with the construction of Sulby reservoir but this has been addressed by the construction of lime dosing plants. There is little particulate pollution load in local watercourses.

There is some diffuse agricultural pollution from slurry and also some point-source from storm overflows and sewage discharges. These are being dealt with through agricultural management plans and the Government's IRIS (integrated sewage system) programme. Monitoring carried out since 1995 has shown compliance with the Government's targets that 98% of the rivers on the Island should achieve fair and above quality measured by biological and chemical monitoring.

There exists the potential for saline infiltration at the coastal fringe due to sea level rise, which would impact on the marginal ecological communities.

No groundwater pollution problems were reported specifically and any such pollution would pose no threat to supplies as all potable water is drawn from upland reservoirs. There are no significant aquifers on the island due to the geology, which comprises mainly shales, mudstones, silts and igneous rocks.

Nuclear The Isle of Man is located in the middle of the Irish Sea, some 55km from the Sellafield Nuclear Fuel Reprocessing Plant. Seafood landed on the Island contains low levels of radionuclides associated with effluent discharges from Sellafield to the Irish Sea. There has been a decline in levels recorded since 1998. The UK government response to climate change, diminishing oil reserves and energy security will dictate whether nuclear power generation is scaled back up.

Minerals The natural resources of the Island are predominantly related to its landscape character. There is considerable lead and zinc mineralisation on the island but what was commercially exploitable has been worked out. There are no hydrocarbon resources associated with the island and therefore all coal, oil and gas must be imported.

There are a number of small quarries on the island. Various rock types worked out of these quarries have been used for building purposes. It is not known how many years of reserves

are left to be worked. Other bulk building materials such as cement, plasterboard etc. have to be imported.

Geology The Island is composed of an ancient solid rock core that forms the range of hills that stretches obliquely across the island, rising to Snaefell at 621m and, where it meets the coastline, forms steep cliffs. The lowlands are in filled with glacial tills, which erode to form terraces and there are many steep-sided valleys with woodland glens towards the sea. The low-lying northern plain has a variety of soft, late glacial deposits, from gravels to sands and clays, which at the coastline form soft cliffs with quite rapid erosion over much of the length and only a little accretion. Although the soils are generally acid there is much diversity and a good range of semi-natural habitats occur across the island. The fertile agricultural soils are found around the coastal plains flanking the hills and in the northern plain, where the largest area of higher-grade class soils are found.

Landscape The landscape and wildlife character of the island is closely linked to habitat and climate. Particularly precious habitats include:

- Brooghs and wet flushes
- Curraghs, which are important roosts for hen harriers: the island supports the largest breeding colony in Western Europe
- The Ayres on the northern tip of the island are internationally important heathland dominated by lichens
- Heather and gorse-rich land seaward of Marine Drive is the home of the Grey Moth
- Rich coastal waters that attract divers and researchers, whale watchers etc. are very temperature-sensitive

Biodiversity The Curraghs are now very important for wildlife, forming a mosaic of willow and bog myrtle scrub, sphagnum bog, open water and flower-rich hayfields. They are internationally important for a communal winter roost of Hen Harriers. Another important habitats is the maritime heath, with heathers and gorse which are important to nature conservation in the British Isles as a whole, since it is the home of the Grey Moth. Other areas include heathland and sheep-grazed grassland. There are bracken-covered steep 'brooghs' (slopes) and wet flushes which are home to unusual plants such as the parasitic Sundew, and heath-loving insects such as Tiger Beetles and Dark-green Fritillary butterflies.[35]

The Ayres are internationally important for its wildlife, particularly the extremely rare lichen dominated heath. The Ayres stretches from Blue Point in the west to the Point of Ayre in the east. Manx National Heritage owns a small but representative part, including marram grass-covered dune and 'gaelic' heath, the latter characterised by its mix of heather and low-growing western gorse. Orchids and Burnet Rose are specialities, and the dunes are home to many species of burrowing beetles and solitary wasps and bees.

There are seventeen mountain and coastal National Glens spread around the Island, preserved and maintained in a semi-natural state by the Forestry, Amenity and Lands Division.

The attractiveness and amenity value of the countryside and its wildlife are widely recognised as a major contributor to the quality of life enjoyed by the Manx public and to attracting visitors to the Island.

[35] Manx National Heritage Website http://www.gov.im/MNH/

Conservation of the environment and wildlife habitats continues to grow in importance as does pressure on land use from development. The Government is developing a Countryside Stewardship Scheme to reward the farming community for their good stewardship of the Island's most valued resource – the land.

The official recorder for the British Trust for Ornithology on the island indicated that most of the birds seen on the island are well within their usual geographical range and would not be significantly affected by climate change in terms of average temperature increase unless the changes were large. He did, however, note that the populations of seed-eating birds had declined and speculated that wetter-than-normal spring nesting periods could be harmful to populations. Most species, especially those that are water-based are thriving.

The Monarch report [36] has undertaken detailed research into modeling natural resources responses to climate change. Certain species and habitats outcomes where identified as being relevant for the Island within the report. *Modiolus modiolus* is a mussel, which has a semi-infaunal growth habit and forms partial or true reefs around several areas of the British and Irish coasts. It has been detailed within the Monarch report as being present in Isle of Man. It is a boreal species, which reaches its southerly limit within Britain and Ireland and thus its distribution pattern here may be sensitive to warming. It is possibly susceptible to summer warming but other threats include scallop dredging and other fishing.

Within the Monarch report the Montane heath habitat which is found on the Island has been identified as being the most sensitive to climate change. The dwarf Willow (salix herbacea) that is found on Snaefell is considered to be a 'loser' within the report. As temperature increases habitats found at higher altitudes will become 'squeezed' as there they cannot move up higher.

The Upland Hay Meadow habitat within the Monarch report shows that species composition is likely to shift but other studies show that this depends on the responses by agriculture to climate change.

The Peat Bog Habitat shows that some elements of this habitat are sensitive and within the south and east of Britain and Ireland there may be some loss of suitable climate space. This may be applicable to the Isle of Man and will need to be assessed. It does indicate that bog myrtle *(Myrica gale)* and sphagnum moss *(Sphagnum papillosum),* which are found on the Island, should be 'winners'. Other habitats, which have been assessed by the report that could provide useful information for the Island, are the Coastal Dune Slacks and coastal estuaries habitats.

[36] Harrison, P.A., Berry, P.M. and Dawson, T.P. (Eds.) (2001). Climate Change and Nature Conservation in Britain and Ireland: Modelling natural resource responses to climate change (the MONARCH project). UKCIP Technical Report, Oxford.

Stage 1 and 2: Natural resources and environmental quality

Defining the issue
Natural Resources and land environment
Response
Environmental quality covers all aspects of the environment including air, water, land and sea. Nuclear pollution was considered a threat to the Island's environment. The environment is considered a huge asset to the Island. One of the issues that the Island faces is whether there are sufficient mineral reserves for future building proposals. The government is completing an investigation into the proposals for and implications of offshore mineral extraction and further offshore hydrocarbon exploration. Also a consultation exercise is being undertaken with the relevant public and private sector organisations to identify current mineral reserves and likely future demand levels recognising the need for the sustainability of those reserves. Other issues include air quality as targets are regularly exceeded for particulates and ozone. Water quality in rivers has also been indicated as a concern as the quality is unsatisfactory in some rivers. The ISIS programme of upgrades to the sewerage system is well advanced and this will lead to improvements in water quality. One key decision to be taken will be whether to preserve the existing environment or let it change under climate change. When considering the problem issues that should be taken into account are: • Failure to take a long-term perspective • Lack of baseline data restricts ability to measure progress • Limited expertise on the Island • Monitoring programmes for toxic algal blooms and shellfish contamination.. The main issue has been defined as: **How can we protect the natural environment to enhance the well-being and economy of the population of the Isle of Man in the face of climate change?** When considering the problem the following should be taken into consideration: ▪ Health impacts ▪ The natural environment ▪ Outside influences on the Island ▪ Water quality ▪ Agriculture

- Fisheries
- Minerals / land management

Stakeholders include all Government Departments, agriculture, forestry and fisheries groups, the Water Authority, land owners, UK government, marine interests, conservation groups, environmental groups.

Current activities on the Island

- Data is already being collected on SST, salinity and nutrient data.
- Change in bee behaviour has been observed
- Sustainability working group is currently developing a 'sustainability toolkit' for all government policies and projects.
- Housing pressures are mainly for affordable housing. Some pressure on the countryside, but most of the building is in town and village extensions.
- Rural housing has affordability issues e.g. for farm workers.

Stage 3: Natural resources and environmental quality

Climate change impacts		
	Potential Risks and Opportunities	
	Biodiversity	**Landscape**
Increasing summer temperatures (H)	• Change of species indeterminate (A) • An increase in insects is good food for bats and fish (A) • Changing water quality / quantity may effect river habitat and biodiversity (S) • Rare species could be favoured by warmer temperatures (S) • Increasing temperatures are expected to accelerate loss of organic matter in soils, releasing nitrogen, which may increase plant growth or, if leached from the soil, increase pollution of watercourses.[37] • Provision of more food e.g.insects and therefore enhance biodiversity (A)	• More fires because of higher temperatures and less rainfall (A) • Upland sources from peat covered catchments are likely to contain enhanced levels of dissolved organic carbon, particularly when re-wetting follows drought periods, producing risks of trihalomethane formation on disinfection with chlorine[38]
Increasing winter temperatures (H)	• Less winter die-off of sensitive species (A) • Bats more active in winter (A) • More intense downpours and droughts (A) • Freshwater biota could be threatened by higher water temperatures and altered river flows (A) • Species suited to a harsher winter climate will be affected (S) • Amphibians may benefit from warmer wetter winter conditions[43] • Hibernating species may be detrimentally affected by warmer winters that disrupt hibernation patterns[43] • Increased risk of mass mortalities of commercial species at extreme of geographical range (A)	• Sulphur oxidised in catchments which is then pushed into rivers and so not seeing benefits of SO2 emissions reductions (A) • Loose materials put on agricultural lands are washed off fields e.g. muck spreading, fertiliser, seed stock (A)
More extreme high temperatures (H)	• Mortality of animals/plants at extreme of geographical range (A) • Increased temperature stress on cold water fish species[43]	• Increased risk of heather fires in upland areas (R) [13] • Changing tree types in Glens (A) • Distributed bogs and sparsely vegetated peat surfaces are likely to suffer increased erosion due to increased rainfall intensity and cracking in summer drought[43]
Less extreme low	• Insect pests are a negative but widely observed consequence of biodiversity	• Increased erosion of footpaths / bridleways as no snow

[37] Bisgrove, R. and Hadley, P. (2002) *Gardening in the Global Greenhouse: The Impacts of Climate Changeon Gardens in the UK*. Technical Report. UKCIP, Oxford.

[38] Health effects of climate change in the UK. Department of Health UK.

temperatures (H)	change (A) • Survival of migratory species that currently arrive, breed and die-off e.g. butterflies (A) • Pest die-off reduced in winter (A)	cover protection (R) [13]
Higher winter rainfall (H)	• Wetter-than-normal spring nesting periods could be harmful to bird populations • Increase in pollutant/nutrient run-off to sea (A) • Soil loss from un-vegetated land (A) • Increased winter rainfall may raise water tables enough to kill roots, thereby reducing effective rooting depth and making trees more vulnerable to summer drought [39]	• Soil erosion (A) • More housing required for animals in the winter – aesthetic impact • Flooding affecting erosion on hill land sending terminal moraine into rivers (A) • Land drainage/erosion/flooding (A) • Increased erosion of footpaths / bridleways as heavy precipitation events cause greater erosion rates (R / O) [13] • An impact on seasonal wetlands – perhaps new wet areas. There will be an increase in erosion, mainly in west and northern river valleys (A) • Increase in number of landslips on northern hills, which is already being seen as they are on sands and gravels. Need to consider land drainage (A) • Higher winter water tables may mean impact on soakaways and septic tanks not working. Already observing higher water tables and impact on septic tanks – as they are not draining away so pools on surface of ground. Note this could be a public health risk. Options could be to improve treatment and pumping systems (A)
Less summer rainfall (M)	• Drying out of wetlands in summer (A) • Lower summer river flows providing less dilution for existing discharges – river quality problems (A) • Adverse affect on marine life (A)	• Decrease in summer soil moisture [40] • Increased incidence of forest fires
More intense downpours (H)	• More frequent sewer overflows causing river quality problems (A) • Effect of extreme weather events such as floods: increased risk of pathogens breaching the water treatment and sanitation safeguards	• Damage to plant species (A) • More flooding of farmland (A)
Sea level rise and increased coastal	• Tidal limits to extend inland, preventing natural flow and dispersion of existing discharges	• Coastal defences to be increased, 0.5m of sea level rise will jeopardise the IRIS installation on Douglas Prom and

[39] http://www.forestresearch.gov.uk/fr/INFD-5ZYJ62 Forest Research Website Impact of climate Change.

[40] National Farmers Union Climate change and Agriculture Nov 2005

flood risk (H)	• Loss of breeding and winter feeding grounds for waders is expected due to sea level rise[43]	all the new apartment dwellings (A) • Increased coastal erosion affecting coastal roads (A) • Erosion of coastline - loss of land (A) • Increase in salt marsh environment (rare in the IoM) (A) • Loss of beaches and reduced inter-tidal area, hard defences might prevent their 'migration' (A) • Salt water intrusion and inundation could affect habitats and land (A)
Possibly more winter storms (L)		• Increased damage/destruction to/of harbour walls (A) • Sea water flooding of existing urban areas (A)
General	• Decreased quality of drinking water (A) • Enforcement is a major issue / monitoring. There is only one planning enforcement officer (A) • Loss of upland species (S)[41] • Increased pest species (S) • Enhanced plant growth (S) • Changes in species' competitiveness (S) • Changes in insect and bird breeding patterns (S) • Loss of fish spawning sites (S) • Potential loss of species from region (S) • Opportunities for range expansion of habitats and species (S) • Potential for species extinction • Causing shifts in the reproductive cycles and growing seasons of certain species[42] • Increased photosynthesis and reduced water use by plants; effects at ecosystems level are unclear.[43] • Conditions may favour ruderal 'weedy' species at the expense of stress tolerators[43] • Changes in predator / prey relationships[43] • Changes in population growth rates and increased numbers of generations[43] • Change in the timing of salmon spawning in response to altered river flow	• Adaptation in response to climate change could have implications for natural resources. E.g. people moving away from flood prone/ coastal areas could end up building in other (natural) areas – who will stop them? (A) • Changing vulnerability / desirability of different locations and impacts on natural resources. (A)

[41] Changing by degrees: The impact of a changing climate on the Northwest of England.

[42] Gitay, Sarez, Dokken and Watson 2002. Climate change and biodiversity IPPC Technical Paper V

[43] J.E. Hossell, B. Briggs and I.R. Hepburn Climate Change and Nature Conservation A review of the impact of climate change on UK species and habitat conservation policy
[44] Bisgrove, R. and Hadley, P. (2002) Gardening in the Global Greenhouse: The Impacts of Climate Change on Gardens in the UK. Technical Report. UKCIP, Oxford.
[45] Robert A. Robinson1, Jennifer A. Learmonth2, Anthony M. Hutson3,Colin D. Macleod, Tim H. Sparks, David I. Leech1,Graham J. Pierce, Mark M. Rehfisch1 & Humphrey Q.P. Crick. BTO research report 414 Climate change and migratory species Jan 06

	conditions[43] • Climate change will alter the probability of invasive and alien species establishing, which may have important effects on local biodiversity.[45] • The impacts of climate change on plants in gardens will be less than on those in the natural environment because of the attention they receive in cultivation.[44] • Experiments show that doubling carbon dioxide levels can increase plant growth by as much as 50 per cent, although this varies depending on plant species, temperature, water supply and mineral nutrient availability.[44] • The wintering areas of bird populations are changing as a result of climate-driven changes in migratory behaviour. In response to warmer temperatures, many waders, such as the Ringed Plover, are now wintering on the east of Britain (closer to their breeding grounds) rather than the west coast. (O / R)[45]	

Stage 4: Natural resources and environmental quality adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Legal requirement to report fires / extinguish them • Put best practice guidelines in place for erosion management • Eco tax • DAFF, DLGE, Island Agenda 21 have role to play in developing All Island Strategic plan (win win) • All Island Strategic plan needs to take account of climate risks e.g. floods and changes to agriculture (win win) • Biodiversity is strongly influenced by land use and so policy responses should be developed in terms of integrated land use management • Manage protected and designated areas. Integrated land use and management strategies developed • Fully integrate habitat conservation and creation with other types of land use through agri-environment and forestry schemes and cross compliance measures. At all scheme reviews, assess whether these measures are delivering at a level that keeps up with the pace of climate change.	• Environmental laws • Plan for habitat change in site protection (flexible) • Fire risk preparation – agree access routes for fire engineers, supplying first defences (e.g. fire beaters) (no regret)	

	Research / Data collection / Monitoring	• Monitoring damage caused by erosion • Species and habitat monitoring - set up central biodiversity centre (no regret) • Maintain and monitor terrestrial, fresh water and marine environmental data (no regret). This also forms part of wider network e.g. UK and Ireland. Irish sea co-ordination will be lost with other studies e.g. EU projects (as IoM are not eligible for these alone). • Government needs to take the lead and get better involved in other for a e.g. BIC • Initiate (continue?) coordinated monitoring programs of environmental factors under single control with dedicated budget • Effects of increased water table on lowland environments • Bird monitoring (just started) No regret • Need to monitor river flow rates; phytophthora, groundwater levels, species taking over. E.g. Bracken encroaching upwards on moorland. The frost keeps it off the top of the hills at present but this may change. (No regret) • Need all island monitoring system and central collection point, which is computer based. Co-ordination of agencies and volunteer agencies to agree on central system (no regret) • As a small island with limited resources need to prioritise on monitoring e.g. indicator species for each habitat. • Understand socio-economic impacts on agriculture • Monitor the impacts of climate change on both common and rare plants including phenology, distribution and status.[46]	• Research on forest / tree pests / diseases so can adapt tree species choice. (win win)	

[46] Under Pressure. Climate Change and the UK's wild plants. By Plantlife. http://www.plantlife.org.uk/uk/plantlife-saving-species-publications.html

	Educational / Behavioural change / Awareness raising / working in partnership	• Education of public to fire threat and management. • Educate about erosion management • Voters need to know what government is investing in e.g. adaptation to climate change and how they can support it. • Need to educate MHKs on climate change, use Manx Radio and explain relevance to the island. Need to lengthen their outlook horizon • Food mile labelling required so people know where food comes from and can buy in an informed way • Need to engage treasury and explain economic implications of climate change and get them to consider environmental and social issues and not just cost. • Undertake cost benefit analysis on major capital projects and take account of climate change. Design climate change in early to save £. Maybe use lifetime costing to account for full costs. • Making information on climate change readily available to farmers and the industry[47] • Revision of policies to encourage diversification of income[47] • Introducing policies to aid adaptation to climate change on livestock farms[47] • Demonstration farms for new crops and techniques[47] • Better water resources planning; and information on 'best practice' techniques for soil conservation in a shortened cultivation window[47] • Promotion and undertaking of good soil management	• Extend business planning process • Promote all projects and expenditure – at point of development (e.g. on a new coastal defence 'built as part of climate change response') • Provide incentives for saving water e.g. reductions on rates for households with water saving devices in toilets • Food miles labelling • Assess impact of climate change on employment sectors and adapt tertiary education to meet expected skills in long term	• Include in all departments business planning process (low regret)

[47] The Timescale Of Potential Farm Level Responses And Adaptations To Climate Change In England And Wales Taken from Project Summaries Report 1987-2002. Defra

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Management plans in place for managing fires • Fire beaters to be put in place of risk • If insurance is required, encourage the financial sector to examine if there is a good business opportunity for IoM insurers • Increase resilience by reducing other stresses • Agri-environment schemes for biodiversity	• Different mechanisms of water storage for reduced summer availability • Drought resistant crops? Introduce different crops	
	Accept impacts and bear Loss	• Joined up thinking across government and treasury (low regret) • Create an environment agency / climate change department with a budget (low regret) • Manage retreat encourage new habitats and increase biodiversity (Win win) • Increase in sea temperatures are associated with algal blooms • Do not sanction additional hard defences in non urban areas – likely to adversely affect natural resources.	• Natural and facilitated migration • Ecological change / biodiversity (win win)	• Footpath repair / erosion damage correction • Increase in variability of river flow, less diversity inverts less fish and the associated knock on effect on ecosystem (no regret)
	Prevent effects: structural / technological	• Fire plans – these are already been done • Agricultural land use adaptation (win win)	• Improve riverbank management to provide some counteraction to climate change impacts on habitat quality and availability	

	Avoid / exploit changes in risk	• Close areas of environment that are high risk fire areas / areas of high erosion • Incorporate opportunities to facilitated colonization in agri-environment schemes, flood defence schemes and coastal planning. • Raise profile of issue and implication to land managers to allow evolution of management (win win) • Exploit opportunities stemming from climate change e.g. grow exotic fora – not oaks • Upgrade existing surface water drainage systems and rivers to deal with significant rainfall events and flash floods • Reducing run off, through use of contoured hedgerows and other buffer vegetation strips • Managed coastal retreat • Habitat management • Develop and fund landscape scale management schemes that establish networks of suitable habitats (such as ponds, hedgerows and small woods) for migrating species as well as providing suitable receptor sites for incoming seeds and spores. • Conserve genetic variation at local sites and increase species and habitat resilience through increasing the size, number and interconnectivity of sites.	• Facilitated colonisation[48] • Adapt forestry to suit new migrating birds	• Flooding

[48] Potential UK adaptation strategies for climate change May 2000 , produced by ERM for the department of the environment, transport and the regions

acclimatise commentary

The natural environment will be significantly affected by climate change. A lot of research has already been undertaken on this sector. Habitats and natural resources are sensitive to climate and the Island is already beginning to experience change.

Climate change needs to be built into land management plans. There will be difficult decisions ahead not least with regard to the conservation of 'at risk' areas already under stress.

The environment is a significant asset to the Isle of Man and climate is one of the key determinants of species distribution and habitats. As the climate changes, the distribution patterns of species and the composition of habitats will change. As the Monarch report states, 'if we are to understand the likely changes and so assess the vulnerability of different species, as well as their ability to adapt, we need to understand how current patterns of distribution are related to our climate.'[36] This is a key action within building adaptive capacity for the Isle of Man as there is a need to gather more baseline data so progress can be measured and benchmarked.

As shown in the Monarch report there will be a shift in species – some species will thrive and 'win' from the changing in climate, but others – in particular montane species – will have their 'climate space' reduced and will be threatened by climate changes.

Other pressures on the environment will increase through climate change. Increased visitor numbers may mean there is more footpath erosion, greater fire risk or even increased development as population grows. (This is discussed in the leisure and recreation section). A sustainable approach that is forward looking needs to be incorporated into biodiversity plans.

Examples of risk

- Increased temperature stress on cold water fish species
- Climate change will alter the probability of invasive and alien species establishing, which may have important effects on local biodiversity
- Drying out of wetlands in summer (A)
- Lower summer river flows providing less dilution for existing discharges – river quality problems (A)

Examples of opportunities

- Provision of more food e.g.insects and therefore enhance biodiversity
- Amphibians may benefit from warmer wetter winter conditions
- Opportunities for range expansion of habitats and species

Potential adaptation options

- Managed retreat, encourage new habitats and increase biodiversity
- Manage protected and designated areas. Integrated land use and management strategies developed

- As a small island with limited resources need to prioritise on monitoring e.g. indicator species for each habitat.

14. Marine environment

Technical reports 3 and 4 outlines evidence for changes in the marine climate, including change in the North Atlantic Oscillation (NAO), storminess, mean sea level and wave and storm surges. Although some records and data sets are short and inconsistent, there is little doubt that the marine environment is responding to a warming of the atmosphere.

The North Atlantic Oscillation is considered to be one of the most influential indicators of climate variability in the northeast Atlantic region[49]. A recognised feature of the NAO in recent times is its propensity to a more positive phase over the past 30 years, which results in warmer and wetter conditions in northern Europe, associated with stronger than average westerly airflow. With regard to storminess, there is evidence for an increase in storm intensity in the North Atlantic region during the 1980s and 1990s, and a higher frequency of severe gales after 1990 which can also be attributed to the positive phase of the NAO[50].

The waters surrounding Ireland and the UK are 7° to 8°C warmer than the average global sea surface temperature at the same latitude principally due to the influence of the warm North Atlantic Drift which is the main ocean current affecting the region[49]. Scottish and Irish sea surface temperatures (SST) have increased since the 1970s, with Scottish temperatures increasing by ~1°C with warming most apparent in winter[51]. Sea surface temperatures from Port Erin have also increased, by 0.7°C since the early 1900s, with a greater rate of increase since 1989.

Other important factors which show evidence of change in the Isle of Man marine climate include wave heights and sea level rise. Waves are the driving force behind every coastal process[52]. Wave heights are determined by the distance of uninterrupted open water over which a wave forming wind can travel, called the fetch. Wave heights in the North East Atlantic have been increasing since the 1960s according to Bouws *et al.* (1996)[53]. Significant wave heights are derived from the mean of a series of wave height measurements taken over a particular time period and are indicative of average wave height conditions[54]. As the Isle of Man is sheltered in the Irish Sea, away from the Atlantic Ocean, significant wave heights are lower, ranging from 0.5 to 1.5 metres (compared to 2.5 to 4 metres in the Atlantic). It is the north west coast of Ireland and Scotland, which are likely to experience the greatest impact of increases in wave height as they are exposed to the full influence of the North Atlantic Ocean. Although considered extreme, wave heights in excess of 24m have been recorded in the Atlantic in the past[52].

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[49] Boelens, R., Minchin, D and O'Sullivan (2005) Implications for Ireland's marine environment and resources. Marine Foresight Series, No. 2. Marine Institute, Ireland.

[50] Jones, P.D., Horton, E.B., Folland, C.K., Hulme, M., Parker, D.E. and Basnett, T.A. (1999) "The use of indices to identify changes in climatic extremes" in Karl, T.R., Nicholls, N. and Ghazi, A. (eds) *Weather and climate extremes: Changes in variations and a perspective from the insurance industry*, Kluwer Academic Publications. The Netherlands.

[51] Scottish Environment Statistics Online, 2005 Scottish Environment Statistics Online (SESO) (2005) Commentary for coastal sea temperature differences at Millport, Peterhead and Fair Isle: 1953 – 2003. http://www.scotland.gov.uk/stats/envonline/select.asp?id=22&cat=1&des=Climate+Change+and+the+Ozone+Layer&Loc=Internal&chart=

[52] Pethick, J. (1984) *An Introduction to Coastal Geomorphology*. Edward Arnold, London.

[53] Bouws, E., Jannink, D., Komen, G.J., (1996) The Increasing Wave Height in the north Atlantic Ocean, *Bulletin of the American Meteorological Society*, 77, 10, 2275-2277.

[54] Fealy, R. (2001) The impacts of climate change on sea level and the Irish coast. In, Climate Change: Scenarios and impacts for Ireland. ERTDI Report Series No. 15. Environment Protection Agency, Ireland, 189-222.

During the last century, sea level has risen globally by 1-2mm/year, with a rise in sea level in the Atlantic region of 0.3-0.7 mm/year. Relative sea level rise (the net rise discounting isostatic change) around Ireland and the UK averaged ~1mm/year although significant variation within the records occur[55]. Global sea level is affected by a number of factors such as the thermal expansion of the oceans, the contribution made by small glaciers and the influence of changes occurring in the large ice masses of Greenland and Antarctica[54]. Coastal flooding is often mistaken for rising sea levels. However, such events are more often the result of storm surges associated with high tides and on-shore winds. It is clear that the impacts of storm surges will increase as sea level rises[49].

Marine life

The coastline of the Isle of Man is rich in marine life. The Irish Sea contains important populations of sea birds, fish and cetaceans including the bottlenose dolphin, grey seals and basking sharks. Commercial fish stocks such as cod, whiting and sole are now over exploited and considered to be outside safe biological limits[56]. The distribution of marine species is determined by many factors and at many different scales. Large scale environmental variations e.g. changes in water characteristics, including temperature and primary productivity, can determine broad distribution patterns of species and habitats and localised conditions can allow and prevent the development of specific assemblages and species. Key physical parameters determining the distribution of marine species include: wave exposure, tidal stream currents, water temperature, salinity and water quality. Biological factors can also modify community consumption and determine the distribution of species such as source of nourishment, predation pressure, competition for space and food and absence of pathogens. Each of these factors combines and interacts with one another to produce a range of conditions suitable for colonisation by different marine species[57].

The Isle of Man lies fully within the boreal biogeographic province, which results in species association of cold-water origin and limits the migration of warm water species, of Lusitanian origin, into the area[58]. The Irish Sea is generally much cooler than the open Atlantic coasts and supports a more Boreal suite of species (Figure 5).

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[55] Woodworth, P. (1999) A review of the trends observed in British Isles mean sea level data measured by tide gauges. Geophysical Journal International, 136. 651-670.

[56] Irish Sea Pilot (2002) A trial of regional sea management for nature conservation. Joint Nature Conservation Committee Issue no.1.

[57] Emblow, C., Minchin, D., Mayes, E. and Wilson, J. (2001) Climate change and the marine environment. In, Climate Change: Scenarios and impacts for Ireland. ERTDI Report Series No. 15. Environment Protection Agency, Ireland, 141-188.

[58] Jones, L.A., Coyle, M.D., Gilliland, P.M., Larwood, J.G. and Murray, A.R. (2004) Irish Sea Marine Natural Area Profile: A contribution to regional planning and management of the seas around England. Peterborough: English Nature

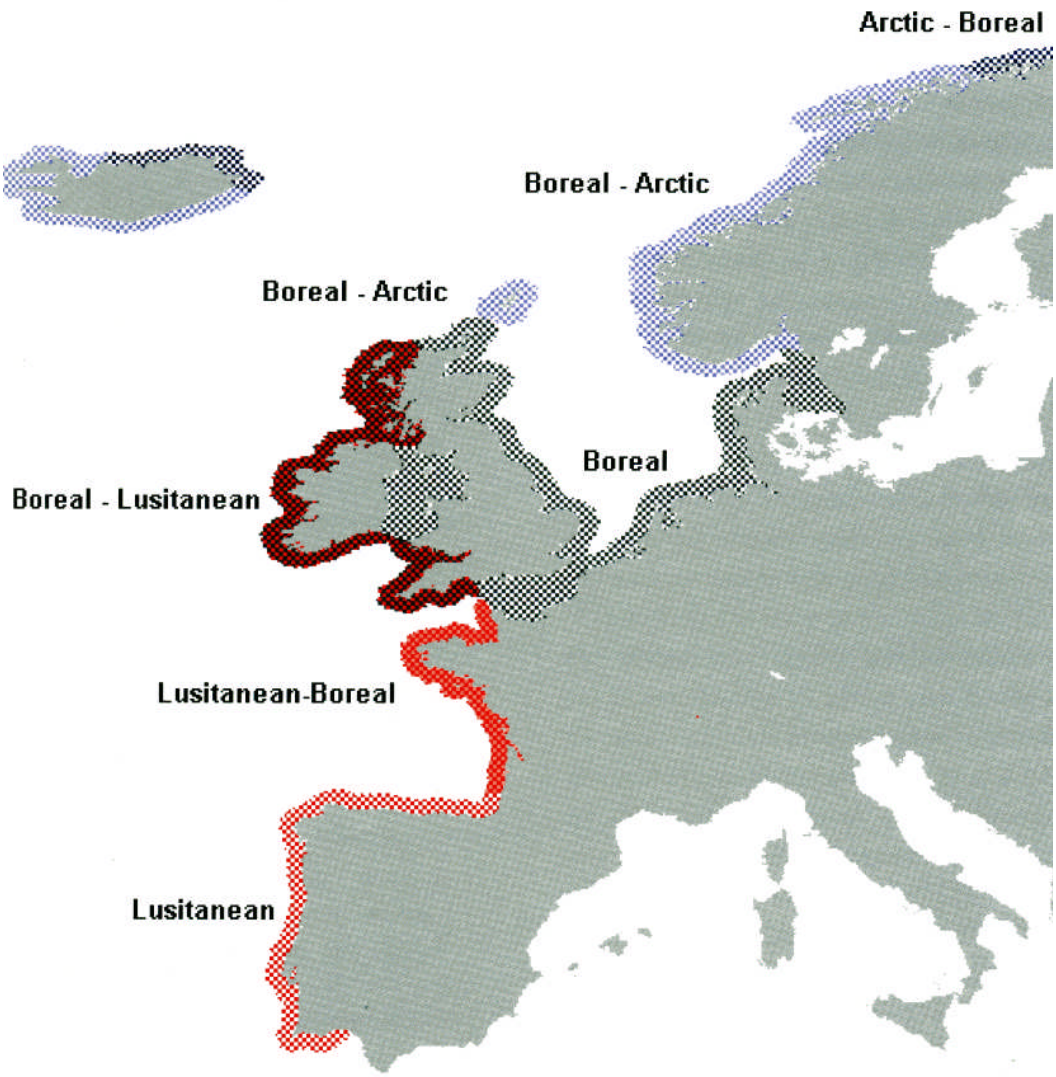

Figure 5: Marine biogeographic regions. Redrawn from Hiscock (1996) Source: Emblow *et al.*, 2001.[57]

Intertidal and sub-tidal species

Evidence suggests that species range extension in response to climatic warming is occurring quicker in marine systems (intertidal species, fish, plankton) than terrestrial systems. MarClim has identified shifts in the geographical limits of species and potential biological mechanisms causing the observed responses of species to climate change. The abundance and distribution of many sea shore species have been altered as a response to increased warming.

Range extensions have occurred at the northern limits of many typically southern warm water species including *Osilinus lineatus* (Toothed topshell), *Gibbula umbilicalis* (Flat

topshell), *Chthamalus montagui* (Montagu's stellate barnacle), *Chthamalus stellatus* (Poli's stellate barnacle) and *Balanus perforatus* (acorn barnacle) since the mid 1980s in Wales, Northern Ireland and Scotland, including greater penetration around the north of Scotland into the colder North Sea[59]. The southern species of barnacles are now more abundant further north. In 2004 *Chthamalus stellatus* (the Poli's Stellate barnacle) was recorded for the first time on the Isle of Man, 100km from the next nearest known population in North Wales[59]. Modelling this species distribution in the future, taking into account modelled sea surface temperatures, wave fetch and future climate change scenarios, an expansion of it's range into the entire north Sea by the 2080s is predicted.

Other barnacles, such as the *Semibalanus balanoides* (Acorn barnacle), a boreal species adapted for cool environments and commonly found on rocky shores, has been found to have it's reproduction inhibited by temperatures greater than 10°C. It is therefore likely to exhibit some sensitivity to temperature change and its distribution may also change due to increased temperatures[57]. The barnacle *Balanus crenatus* (also an Acorn barnacle), in studies in areas of higher water temperature was replaced by a sub-tropical barnacle (*Balanus amphritite*). However, after the water cooled, *Belanus crenatus* returned[60]. Increases in sea temperatures could see this occur in the Isle of Man. Kelp (*Laminaria*) species have been identified as being sensitive to changes in temperature, in particular short term changes, but they can adapt to slow, gradual increases in temperature.

MarClim have found less evidence of a reduction in the ranges of northern species, although some species have not been found on shores where they have previously been recorded. The *Tectura tessulata* (Tortoiseshell limpet), whose previous southern limit was at Dublin and Anglesey has now been lost from the south of the Isle of Man since the 1980s[59].

Hiscock *et al.* (2004)[61] suggest that there will not be a wholesale movement northwards of southern species or retreat northwards of northern species with increasing sea surface temperatures because many additional factors will influence the responses of different organisms. Such factors include the hydrodynamic characteristics of water masses, the reproductive mode of species, the presence of geographical barriers and the longevity of already established species. It is further complicated by the presence of competing species and the presence of prey or predator species. Where species affected by climate change are dominant or key structural or functional species in biotopes, there may be a change in the extent and distribution of those biotopes.

Changes in sea level are likely to have a minimal impact on fishing and sea weed industries. Impacts will most likely be restricted to activities utilising intertidal areas such as shellfish and sea weed harvesting[57].

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[59] Mieszkowska, N., Leaper, R., Moore, P., Kendall, M.A., Burrows, M.T., Lear, D., Poloczanska, E., Hiscock, K., Moschella, P.S., Thompson, R.C., Herbert, R.J., Laffoley, D., Baxter, J., Southward, A.J., Hawkins, S.J. (2005) Marine Biodiversity and Climate Change (MarClim) Assessing and predicting the influence of climatic change using intertidal rocky shore biota. Marine Biological Association Occasional Publications, No. 20.

[60] Naylor, 1965; in Emblow, C., Minchin, D., Mayes, E. and Wilson, J. (2001) Climate change and the marine environment. In, Climate Change: Scenarios and impacts for Ireland. ERTDI Report Series No. 15. Environment Protection Agency, Ireland, 141-188.

[61] Hiscock, K., Southward, A., Tittley, I. and Hawkins, S. (2004) Effects of changing temperature on benthic marine life in Britain and Ireland. Aquatic Conservation: Marine and Freshwater Ecosystems. Vol 14 (4), p333-362.

Fish species and fisheries

Marine species including plankton and fish show rapid responses to alterations in climate. As the climate warms, a general pole-ward shift in species range is expected as species respond to the alteration of suitable 'climate space' they can inhabit [62]. As species have different metabolisms, and different physiological processes and behaviours, they are likely to respond to warming temperatures at different rates. This will also affect adult growth and survival, reproductive output, phenology and recruitment success[59].

According to Emblow et al., (2001)[57] northern species such as cod, which prefer temperatures between 4 and 7°C; herring, which have an optimum temperature for spawning between 8 and 9°C; and haddock, which has a southern limit down to the south of Ireland, may all be limited in their southern distribution by increased water temperature. Similarly, southern species such as hake, may have their range extended northwards. Bass (*Dicentrarchus labrus*) spawn in inshore waters on the south-west and south-east coasts of Ireland. While they are found further north, their numbers are limited. However, increases in sea temperatures may see bass as more frequent visitors to the Irish Sea. Kennedy and Fitzmaurice (1972) found that growth and year class strength of bass was positively correlated with higher sea temperatures (in, Emblow *et al.*, 2001)[57].

There are also detrimental impacts from changing sea surface temperatures. The occurrence of eagle ray (*Myliobatis aquila*) and gilt-head sea bream (*Sparus aurate*) are both considered to have potentially harmful implications for shellfish culture and benthic marine biodiversity. One record of eagle ray occurs from Co. Antrim in Northern Ireland (Vickers, 1959; in, Emblow et al., 2001) and may become more common in Irish Sea waters as it prefers calm conditions in warm months.

Marine mammals

The impacts of climate change are also considered to have a serious threat on cetaceans at both the local and global level. Smaller increases in temperature may have local impacts on the primary productivity of the Irish Sea and thus a local impact on potential food for cetaceans. A shift in plankton distribution and abundance will have implications for seals, dolphins and sharks in the area surrounding the Isle of Man. If there was an increase in severity or frequency of storms, diseased, old or weak cetaceans may be unable to survive more stormy conditions.

There is evidence that predator species are also following the north-ward shift in cold water species. MacLeod *et al.* (2005) examined cetacean strandings, sightings and abundance in north-west Scotland. They found a range extension of common dolphins (*Delphinus delphis*), which is a warm water species, and also a decrease in range of white beaked dolphins (*Lagenorhynchus albirostris*) (in, Simmonds and Isaac, 2005)[63]. Thus, there is direct evidence that warm water cetacean species are also making the pole-ward shift.

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[62] Graham and Grimm, 1990; Fields et al, 1993; Southward *et al.*, 1995; Parmesan, 1996; Sagarin *et al.*, 1999; in, Mieszkowska, N., Leaper, R., Moore, P., Kendall, M.A., Burrows, M.T., Lear, D., Poloczanska, E., Hiscock, K., Moschella, P.S., Thompson, R.C., Herbert, R.J., Laffoley, D., Baxter, J., Southward, A.J., Hawkins, S.J. (2005) Marine Biodiversity and Climate Change (MarClim) Assessing and predicting the influence of climatic change using intertidal rocky shore biota. Marine Biological Association Occasional Publications, No. 20.

[63] Simmonds, M.P. and Isaac, S. (2005) Climate change and marine apex predators: some warning signals. The Whale and Dolphin Conservation Society, UK.

Plankton

Plankton plays an important role in the development of marine and ecological systems. Phytoplankton is responsible for nearly all the primary production in the sea and any significant changes in plankton development could potentially have significant impacts further up the food chain. They have limited mobility and are thus reliant on water movement to determine their distribution and also the optimum environmental conditions for development. As such, sea temperature plays an important role in the timing and development of phytoplankton communities and also in the development of other marine communities further up the food chain[57].

Sea birds

Climate change is likely to impact on seabird populations. Increased storminess, rises in sea level and warmer temperatures as a consequence of greenhouse warming are likely to have a direct impact on seabird populations. Higher sea levels may limit the breeding habitat of some birds, especially those in low lying estuaries and shoreline nesting species such as terns. The predicted increase in storm frequency and severity may impede fishing activities for birds and limit their availability of food. Many of the sea birds that prey on fish and plankton are likely to have their food supply reduced or relocated if the above effects on plankton and fish occur. Winter storms can cause large-scale 'wrecks' of seabirds while summer storms can wash whole colonies from cliffs[64]. Other factors can impact on sea bird populations such as fisheries management and botulism induced mortality for example due to herring gulls feeding at tipheads[57]. However, the mobile nature of birds means that they have the ability to move to warmer or less stormy regions.

[64] Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. (2004) Seabird populations of Britain and Ireland. T & A.D. Poyser, London.

Stage 3: Marine environment

Climate change risks		
Marine Environment	**Potential Risks and Opportunities**	
	Coasts	**Marine life**
Increasing average temperatures (H)	• Under the medium-high emission scenario all areas show an increase in temperature of coastal sea water, with temperatures around the Isle of Man warming by between 1.5-2°C by the 2080s. For the low emissions scenario, warming ranges from 0.5-1°C, while for the high emissions scenario the warming is between 2° and 2.5°C[65]. Temperature increases in this range will affect both the diversity and abundance of marine life around the coast. • Changes could occur in the timing and level of primary production, in feeding patterns, in the growth and behaviour of individual species and also in community structure and stability[49].	• Where change is slow, occurring over decades, it would be expected that most biological communities would adapt[49]. • Shifts in the geographical limits of species • The abundance and distribution of many sea shore species have been altered as a response to increased warming • Range extensions have occurred at the northern limits of many typically southern warm water species • The southern species of barnacles are now more abundant further north. In 2004 *Chthamalus stellatus* (the Poli's Stellate barnacle) was recorded for the first time on the Isle of Man, 100km from the next nearest known population in North Wales[59] • Other barnacles, such as the *Semibalanus balanoides* (Acorn barnacle), a boreal species adapted for cool environments and commonly found on rocky shores, has been found to have it's reproduction inhibited by temperatures greater than 10°C. It is therefore likely to exhibit some sensitivity to temperature change and its distribution may also change due to increased temperatures[57] • Kelp (*Laminaria*) species have been identified as being sensitive to changes in temperature, in particular short term changes, but they can adapt to slow, gradual increases in temperature. • Loss of species from the Island e.g. *Tectura tessulata* (Tortoiseshell limpet), • a general pole-ward shift in fish species range is expected as species respond to the alteration of suitable 'climate space' they can inhabit • Increasing warning will affect adult growth and survival, reproductive output, phenology and recruitment success[59]. • Cod, herring and haddock may all be limited in their southern distribution by increased water temperature

[65] Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy. J.M., Hassell, D., Boorman, P., McDonald, R., Hill, S. (2002) Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report. Tyndall Centre, School of Environmental Sciences, University of East Anglia, Norwich, UK, 118pp.

		• Southern species such as hake, may have their range extended northwards • Kennedy and Fitzmaurice (1972) found that growth and year class strength of bass was positively correlated with higher sea temperatures[57] • The occurrence of eagle ray (*Myliobatis aquila*) and gilt-head sea bream (*Sparus aurate*) are both considered to have potentially harmful implications for shellfish culture and benthic marine biodiversity and may become more common in Irish Sea waters as it prefers calm conditions in warm months • There is direct evidence that warm water cetacean species are also making the pole-ward shift.
More extreme high temperatures (H)		
Less extreme low temperatures (H)		

Sea level rise and increased coastal flood risk (H)	• Accounting for isostatic adjustments, a sea level rise of between 8 and 54cm is projected for the 2080s based on IPCC medium-high emissions scenarios. If this rise was to occur coastal habitats would be particularly susceptible. • Parts of the coast would experience greater levels of erosion • More frequent breaching of coastal defences • In low-lying areas, for example along the north and east coasts, increased flooding • Gradual loss of habitats and amenities. • Low lying coastal areas, such as estuaries and coastal lagoons, are likely to be most vulnerable and significantly affected by sea level rise. • Coastal lagoons that have a specific salinity regime maintained by a coastal barrier may be particularly vulnerable to small sea level rises[57] • Estuarine systems, saltmarshes, mudflats and shingle beaches are some of the coastal habitats which may be subject to 'coastal squeeze', where they are encroached by urban areas and rising sea level at the same time.	• Higher sea levels may limit the breeding habitat of some birds, especially those in low lying estuaries and shoreline nesting species such as terns • Winter storms can cause large-scale 'wrecks' of seabirds while summer storms can wash whole colonies from cliffs[64].
Possibly more winter storms (L)	• However, with rising sea levels and the possibility of increased frequency and/or intensity of storm surges, saltmarsh, sand dune and shingle ridge habitats are expected to be increasingly vulnerable to erosion[66]	• If there was an increase in severity or frequency of storms, diseased, old or weak cetaceans may be unable to survive more stormy conditions. • The predicted increase in storm frequency and severity may impede fishing activities for birds and limit their availability of food. Many of the sea birds that prey on fish and plankton are likely to have their food supply reduced or relocated if plankton and fish are affected by climate change.

[66] Harrison, P.A., Berry, P.M. and Dawson, T.E. (eds) (2001). Climate change and nature conservation in Britain and Ireland, modelling natural resource responses to climate change. UKCIP Technical Report, Oxford, UK.

General / Indirect effects		• No change in distribution as Hiscock *et al.* (2004)[61] suggests that there will not be a wholesale movement northwards of southern species or retreat northwards of northern species with increasing sea surface temperatures because many additional factors will influence the responses of different organisms. • A shift in plankton distribution and abundance will have implications for seals, dolphins and sharks in the area surrounding the Isle of Man. • Plankton plays an important role in the development of marine and ecological systems. Phytoplankton is responsible for nearly all the primary production in the sea and any significant changes in plankton development could potentially have significant impacts further up the food chain

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The Isle of Man, like the rest of Europe, has become warmer in recent decades. The 1990s have been recorded as the warmest decade of the 20th century. There is also evidence of warmer autumns, significant increases in night-time minimum temperatures, reductions in the number of frost days and increasing rainfall in the east (Douglas) in spring and decreasing rainfall in the south (Ronaldsway) in summer. There are also clear signs that the marine areas around the United Kingdom and Ireland are changing in response to the warming of the atmosphere. Higher sea temperatures (across the whole of the Northern Hemisphere), associated with increased wind strength and wave heights all contribute to changes in our coastal ecosystems.

Many of the impacts on the Isle of Man's marine environment and biodiversity will be most apparent in coastal areas. Significant changes in response to increased sea temperatures, more intense storms and wind strength and rising sea level are likely. There is evidence of a disruption in the marine food chain, from plankton to fish to sea birds and mammals. An area not previously mentioned, although possibly increasing in importance, is that of increased acidity in the sea. The effects and impacts are not yet fully understood, but research has found that carbon dioxide is also raising acidity levels in the oceans. As expected this will impact upon marine organisms, especially the shells of coral and shellfish such as crabs and oysters. This would also have major implications all through the food chain. Changes in marine species will occur, although the extent to which this occurs is difficult to predict. The expansion of new species into the coastal area will probably be at the expense of other species, either through reduction of prey, increased competition or exploitation. New fish species will be able to colonise areas where fish sensitive to temperature change are displaced. However, the detailed knowledge of how or when this may occur is still not possible.

For impacts on the marine environment, continued close cooperation with the UK and Ireland, as well as other European studies will expand our knowledge of what is happening in the coastal regions of the Isle of Man and the Irish Sea. There are large gaps in knowledge of species and habitats, so it is difficult to assess what the impacts of climate change will be upon them. Ideally long-term data sets are needed, but in the case where a few exist, they need to be maintained and added to.

There is a need to put a greater emphasis on protecting the marine environment from the changes predicted in sea level and storm surges. Monitoring of habitat change and 'coastal squeeze' are important so that adaptation and mitigation measures can be implemented.

15. Agriculture, fisheries and forestry

Characterisation

The agricultural industry in the Isle of Man has traditionally been based on mixed farming, a reflection of the natural advantage of the Island's ability to grow grass and other fodder crops and a relatively restricted ability to sustain viable arable farming. Soils are not particularly good and the climate is mild but damp, although there are significant variations, with the northern plain tending to be drier. Agriculture has in general been broad-based mixed farming, but in response to commercial pressures, a greater degree of specialisation has developed over the years. Agricultural practices tend to be non-intensive.

The agricultural sector is important in its role its plays in the Island's economy, the social fabric and cultural life of the island, and to the maintenance and conservation of the natural environment and landscape which is particularly valued by the whole community. There are three main areas of agricultural endeavour in the Isle of Man - fatstock, dairy and cereals. The farming practices of all three are inter-linked and the well-being of the three is dependent on the on-going success of the companion sectors.

The Isle of Man is a significant food producer, which exports almost 70% of its production. The ability to trade with the EU is crucial to the survival of the Manx farming industry in its current structure. Though not actually part of the EU, the Island's trading relationship with the EU is substantially defined by Protocol 3, which permits the Island to trade agricultural products freely with the EU, but in exchange requires the Island to broadly match the EU trading regime. This brings the current changing world agricultural policy to bear directly on the Island's agricultural trading regime.

The recent decision by the EU to renew the red meat derogation for a final five years, leads to the biggest pressure to change that the industry has encountered for generations. Whilst the government will continue to challenge the decision, the likelihood of successfully reversing the decision is low, and all policy will progress on the basis of the loss of derogation from 2011.

The attractiveness and amenity value of the countryside and its wildlife are widely recognised as a major contributor to the quality of life for the Manx public and to attracting visitors to the Island and as such contributes to the approximately £125m generated each year from tourism. Conservation of the environment and wildlife habitats continues to grow in importance, as does pressure on land use from development, and, conversely, abandonment of active management of land. The Department of agricultural, fisheries and forestry is therefore working towards the development of a Countryside Stewardship Scheme to reward the farming community for their good stewardship of the Island's most valued resource – the land. It is envisaged that this may be accompanied by an Agri-environment Scheme to enable more targeted changes in farm husbandry.[67]

There is some diffuse agricultural pollution from slurry and some due to sewage discharges. Both of these are being dealt with through agricultural management plans and IRIS (integrated sewage system). In spite of these various sources of pollution, monitoring

[67] Isle of Man government Agricultural services division business plan 2006-2007

carried out since 1995 has shown compliance with Government set targets that 98% of the rivers on the Island should achieve fair and above quality measured by biological and chemical monitoring.

The Forestry, Amenity and Lands Division manage 19,000 acres (7,700 Ha) of hill lands. These are located in two main blocks, the northern hills surround Snaefell (2,036 feet) and extend as far south as Greeba Mountain which overlooks the Central Valley, and the southern block which runs through Glen Rushen to South Barrule and the coastal hills of Cronk-ny-Arrey Laa and Surby. The Department manages over fifty plantations ranging from those of just a few acres to those that cover several hundred acres. The uplands are managed for hill-sheep grazing, to encourage the small population of red grouse and to conserve the valuable wildlife habitats and outstanding natural beauty, which they provide.

Low stocking levels encouraged through Hill Sheep Subsidy help ensure that overgrazing does not occur. The natural process of regeneration of heathland plants is achieved through appropriate mechanical cutting or bush-hogging and also by heath burning which is undertaken through the winter months and which is controlled by the Heath Burning Act 2003.

The Isle of Man allows easy and fast access to all fishing venues enabling any angler wishing to do so the opportunity to catch a wide variety of species. The many piers in the Island offer easy access to lots of very good and varied fishing. Boat fishing in the Isle of Man is mainly concentrated around the rocky south coasts with the main charter boats port being Port. St. Mary which gives easy access to some of the most productive inshore reef fishing in the UK with Pollack to 18lbs being the species which most anglers target although Cod, Ling, Conger, Coalfish, Mackeral, Tope, Wrasse, and Bullhuss are also sought by anglers.

A licence is not required if fishing off a breakwater or beach or boat with a rod and line. However there are certain regulations and requirements for other types of fishing, e.g. fishing for crabs or lobsters using 5 pots or less then you need a licence. There are other requirements such as if a fish that is less than the minimum size is caught it must be returned to the water.

For commercial fishing registered fishing vessels must have the appropriate UK commercial licence. In addition a relevant Isle of Man licence is needed if fishing within 12 miles of the Isle of Man. Licences depend upon the type of fishery and the size of the boat.

Salmon and sea trout are both native to the island and Manx rivers hold surprisingly good stocks of migratory fish. Given enough water, there should be sea trout in the major streams by June, with salmon arriving later in the year, usually by late September. The main streams frequented by migratory fish are the Sulby River in the northern half of the island and the Neb, which flows into the sea at Peel on the West coast. However sea trout can be found in some of the larger pools in the smaller streams.

The Department of Agriculture Fisheries and Forestry operates a fish hatchery at Ballaglass near Cornaa. All the rainbow trout and brown trout released in the Reservoirs are reared at this site. On average approximately 30,000 fish are introduced to the reservoirs over the angling season.

Stage 1 and 2: Agriculture, fisheries and forestry

Defining the issue
Natural Resources and Environmental Quality
Response
The environment is considered a huge asset to the Island. There are two challenges to be faced within agriculture, which are to obtain an extension of the European Union derogation that controls the importation of Beef and Sheep meat and a further derogation on the import of milk and cream. Negotiations with the United Kingdom Authorities have resulted in their full support in respect of this endeavour. Further meetings have been held with European Union Commission officials. The Government remains committed to raising the understanding of the unique trading and constitutional position of the Island and the resulting impact on the Island's agricultural and fishing industries. The Government is also committed to meeting these challenges with the intention of maintaining the Island's rural communities as well as its self-sufficiency in staple food products. The government is currently in the process of re-negotiating the Fisheries Management Agreement it has with the United Kingdom in order to extend the Island's autonomy to frame legislation to the whole of the territorial sea. At present, the Island only has such autonomy out to the three-mile limit. It is the government's intention to negotiate a change to the Agreement, which would give autonomy out to 12 miles. This brings with it the challenge of getting United Kingdom Ministerial approval to go out to consultation with the adjacent jurisdictions. Other issues which have been identified are: • Failure to take a long-term perspective • Lack of baseline data restricts ability to measure progress • Fire management • There is already monitoring for toxic algal blooms and shellfish poisoning but it could become an issue for tourists eating shellfish. • The main scallop fisheries can close to algal blooms. The main issue has been defined as: **How can we provide agriculture, fisheries and forestry services in the face of climate change?** When considering the problem the following should be taken into consideration: ▪ Health impacts ▪ The natural environment ▪ Outside influences on the Island ▪ Water quality

- Socio-economic impacts – changing brought about by changing economic conditions will probably outweigh the effects a changing climate may have.

The problem does not involve managing present day climate directly but will need to consider adapting to future climate change.

Stakeholders include all Government Departments, agriculture, forestry and fisheries interests, Manx Water Authority, land owners, UK government, marine interests..

Current activities on the Island

- Data is already being collected on SST, salinity and nutrient data. There are some very long records and some go back 100 years.
- Review of the agricultural strategy and change in derogations is currently being undertaken
- Housing pressures are mainly for affordable housing. Some pressure on the countryside /agricultural land. Most of the building is in town and village extensions. Rural housing has affordability issues e.g. for farm workers.
- Industry communication on issues is provided by newsletters, technical seminars, farm text and press releases
- National advisory programme
- Adaptation of Islands agricultural support schemes to reflect changes in agricultural trading environment and to reduce administration is being developed by introducing a Country side stewardship scheme
- Full farm mapping underway

Stage 3: Agricultural, fisheries and forestry impact matrix

Climate change impacts			
	Potential Risks and Opportunities		
	Agricultural	**Fisheries**	**Forestry**
Increasing summer temperatures (H)	• Change of species indeterminate (A) • New pests, an increase in insects leading to an increase in disease risk (A) • Lack of water for crops (grass, fodder, or cash) therefore affecting farming throughout the Island (A) • Increasing temperatures are expected to accelerate loss of organic matter in soils, releasing nitrogen, which may increase plant growth or, if leached from the soil, increase pollution of watercourses.[68] • More fires because of higher temperatures and less rainfall (A)	• Salmon mating earlier and smaller – greater potential for thermal shock when go to seawater (A) • An increase in insects is good food for fish (A) • Changing water quality / quantity may effect river habitat and biodiversity (S) • Scallop fishing (increase in sea temperatures are associated with algal blooms)	• New pests, an increase in insects leading to an increase in disease risk (A) • Increasing risk of forest fires (A)
Increasing winter temperatures (H)	• Disease control on crops more difficult (A) • Affects livestock e.g. pneumonia – increasing need for ventilation in farm buildings (A) • Loose materials put on agricultural lands are washed off fields e.g. muck spreading, fertiliser, seed stock (A) • Grass growing season will commence earlier • Less winter chill in fruit[69] inadequate winter chilling interferes with the normal processes of bud formation, flowering and yield. • Reduced vernalisation (cold winter weather required for flowering)[76] • Leave animals in fields for longer / housing period decreased[76]	• Freshwater fish could be threatened by higher water temperatures and altered river flows (A) • Fish spawning earlier (A) • Change in fish species both within rivers and sea (A)	
More extreme high	• Mortality of animals/plants at extreme of geographical	• Increased temperature stress on cold water	• Increased incidence of

[68] Bisgrove, R. and Hadley, P. (2002) *Gardening in the Global Greenhouse: The Impacts of Climate Changeon Gardens in the UK*. Technical Report. UKCIP, Oxford.

[69] Defra Desk top study on Winter chill in fruits. Dr CJ Atkinson, Dr RJ Sunley and Professor HG Jones, Dr R Brennan, Dr P Darby

temperatures (H)	range (A) • Different crops e.g. vineyards (A) • Change in crops and time of harvest (A) • Impact on amount of forage available in times of drought (R) [70] • Damage crops (e.g. wheat, salad crops) at extreme temperatures (R)[76] • Heat benefits some crops (onions, legumes, carrots and sweet corn) (R)[76] • Increased heat stress in livestock (R)[76] • Lack of grazing in drought events[76]	fish species[43]	summer drought would make trees more vulnerable to attack by weak pathogens[39] (R) • Changing tree types in Glens (A)
Less extreme low temperatures (H)	• Extension of growing season (O) • Ability to grow crops that are suited to a warmer climate (A) • Pest die-off reduced in winter (A)		• Pest die-off reduced in winter (A)
Higher winter rainfall (H)	• Heavy rainfall damaging crops (A) • Soil erosion (A) • Increase in pollutant/nutrient run-off to sea (A) • Soil loss from un-vegetated land (A) • Difficulty with harvesting (O)[71] • Reduced yield and / or output (O)[71] • Increased crop drying costs (O)[71] • Increased feed and bedding costs (O)[71] • Reduced lamb production (O)[71] • Indirect effects included damage to soil structure, and increased soil erosion, phosphorus losses, nitrate leaching, nitrous oxide (N_2O) emissions and pesticide mobility (O)		• Winter waterlogging limiting access for forestry[73] • Increasing tree falling due to waterlogging and then dry out of soils (A)

[70] The Timescale Of Potential Farm Level Responses And Adaptations To Climate Change In England And Wales Taken from Project Summaries Report 1987-2002. Defra

[71] The Wet Autumn of 2000: Implications for Agriculture. Defra. Taken from Project Summaries Report 1987-2002. Defra.

[72] http://www.forestresearch.gov.uk/fr/INFD-5ZYJ62 Forest Research Website Impact of climate Change.

[73] Forest Research Annual Report and Accounts 2002- 2003 Climate Change and British woodland, what does the future hold. Mark Broadmeadow, Duncan Ray, Louise Sing and Liz Poulsom

	• Increased housing needed for livestock[71] • Increase in drainage systems[76] • Increase in wet weather related animal health problems / pest and disease problems[75] • Increased winter rainfall may raise water tables enough to kill roots, thereby reducing effective rooting depth and making trees more vulnerable to summer drought [72]		
Less summer rainfall (M)	• Drought affecting farming practices, types of crop grown and livestock reared (A) • Drop in some crop yields[76] • Increased irrigation needs and change in methods (e.g. potatoes)[76] • Decrease in summer soil moisture[76]	• Increased pollution due to low flow rivers affecting fishing (A) • Lower summer river flows providing less dilution for existing discharges – river quality problems (A) • Adverse affect on marine life (A)	• Increased incidence of forest fires
More intense downpours (H)	• Damage to plant species (A) • More flooding of farmland (A)	• Effect of extreme weather events such as floods: increased risk of pathogens breaching the water treatment and sanitation safeguards	• Damage to plant species (A)
Sea level rise and increased coastal flood risk (H)	• Salt water intrusion and inundation could affect agricultural land (A)		
Possibly more winter storms (L)	• More reliance on local food products and strategic supplies (A) • Crop damage / total crop loss (e.g. lodging of wheat, un-harvestable fields from extreme events[76]		

General	• Enhanced plant growth (S) • Changes in species' competitiveness (S) • Increased photosynthesis and reduced water use by plants; effects at ecosystems level are unclear.[74] • Interspecific interactions may alter, particularly favouring ruderal 'weedy' species at the expense of stress tolerators[43] • Shifting demand for consumer's tastes / different produce (A) • Change in crop quality[75] • Increase in carbon dioxide levels could potential stimulate photosynthesis and yields e.g. potatoes, wheat and forage [76] • Increase in cost and range of insurance for agriculture[76] • Increasing diversification[76] • New skills training / differing agricultural workload[76] • Change in agricultural markets, demand and competition[76] • Climate change will alter the probability of invasive and alien species establishing, which may have important effects on local biodiversity.[45] • Experiments show that doubling carbon dioxide levels can increase plant growth by as much as 50 per cent, although this varies depending on plant species, temperature, water supply and mineral nutrient availability.[77]	• Loss of fish spawning sites (S) • Change in the timing of salmon spawning in response to altered river flow conditions[43]	• Reduction in timber quality[73] • Other direct impacts of rising CO2 levels include an increase in leaf area, a possible reduction in timber density and quality (generally ascribed to faster growth rates), a reduced risk of damage from insect herbivores as a result of a decline in the nutritional quality of foliage, a tendency towards an increased allocation of resources to the roots relative to the above-ground tissues and the development of nutrient deficiencies or imbalances, again as a result of more rapid growth.[78]

[74] J.E. Hossell, B. Briggs and I.R. Hepburn Climate Change and Nature Conservation A review of the impact of climate change on UK species and habitat conservation policy

[75] The Royal society. Food crops in a changing climate April 2005 www.royalsoc.ac.uk

[76] National Farmers Union Climate change and Agriculture Nov 2005

[77] Bisgrove, R. and Hadley, P. (2002) Gardening in the Global Greenhouse: The Impacts of Climate Change on Gardens in the UK. Technical Report. UKCIP, Oxford.

[78] The potential effects of climate change for trees and woodland in the South West. A report prepared for the South West Conservancy of the Forestry Commission, funded by the Sustainable Forestry Group of the Forestry Commission. Mark Broadmeadow May 2004

Stage 4: Agriculture, fisheries and forestry adaptation options

	Adaptation Type	Urgent: Opportunities to take advantage of now / decisions needed now / cost effective now	Long term	Keep a 'watching brief'
Building Adaptive Capacity (BAC)	**Prevents effects: Changing standards regulation / policy institutional**	• Legal requirement to report fires / extinguish them • Put best practice guidelines in place for erosion management • All Island Strategic plan needs to take account of climate risks e.g. floods and changes to agriculture (win win) • Manage protected and designated areas. Integrated land use and management strategies developed • Fully integrate habitat conservation and creation with other types of land use through agri-environment and forestry schemes and cross compliance measures. At all scheme reviews, assess whether these measures are delivering at a level that keeps up with the pace of climate change.	• Plan for habitat change in site protection (flexible) • Fire risk preparation – agree access routes for fire engineers, supplying first defences (e.g. fire beaters) (no regret) • Changes in species fished e.g. threatened species protected, more available species promoted • Marketing campaign backup change in fish caught	
	Research / Data collection / Monitoring	• Monitoring damage caused by erosion • Maintain and monitor terrestrial, fresh water and marine environmental data (no regret). This also forms part of wider network e.g. UK and Ireland. Irish sea co-ordination will be lost with other studies e.g. EU projects (as IoM are not eligible for these alone). • Need to monitor river flow rates; phytophthora, groundwater levels, species taking over. E.g. Bracken encroaching upwards on moorland. The frost keeps it off the top of the hills at present but this may change. (No regret) • Investigate changes in crops and different types of trees for forestry under different climate conditions. • Understand socio-economic impacts on agriculture	• Research on forest / tree pests / diseases so can adapt tree species choice. (win win) • Investigate change in pesticides used as changing pests /diseases	

	Educational / Behavioural change / Awareness raising / working in partnership	• Education of public to fire threat and management. • Educate about erosion management • Food mile labelling required so people know where food comes from and can buy in an informed way • Making information on climate change readily available to farmers and the industry[79] • Revision of policies to encourage diversification of income[47] • Introducing policies to aid adaptation to climate change on livestock farms[47] • Demonstration farms for new crops and techniques[47] • Better water resources planning; and information on 'best practice' techniques for soil conservation in a shortened cultivation window[47] • Promotion and undertaking of good soil management	• Food miles labelling	

[79] The Timescale Of Potential Farm Level Responses And Adaptations To Climate Change In England And Wales Taken from Project Summaries Report 1987-2002. Defra

Delivering Adaptation Actions (DAA)	**Spread /Share loss**	• Management plans in place for managing fires • Fire beaters to be put in place of risk • If insurance is required, encourage the financial sector to examine if there is a good business opportunity for IoM insurers • Increase resilience by reducing other stresses • Agri-environment schemes for biodiversity • Encourage diversification of agricultural industry – encourage people in the countryside / use of land	• Different mechanisms of water storage for reduced summer availability • Drought resistant crops? Introduce different crops	
	Accept impacts and bear Loss	• Joined up thinking across government and treasury (low regret) • Create an environment agency / climate change department with a budget (low regret) • Scallop fishing (increase in sea temperatures are associated with algal blooms) – need to ensure food safety monitoring in place		• Adopt forest management systems to accommodate storms (No regret) • Increase in variability of river flow, less diversity inverts less fish and the associated knock on effect on ecosystem (no regret)
	Prevent effects: structural / technological	• Fire plans – these are already been done • Agricultural land use adaptation (win win)	• Agricultural buildings to be adapted • Agricultural related infrastructure may need to evolve to match changes in land use. (No regret / win win) • Enclosed bathing areas on the coasta that affords protection from jellyfish / safety areas	

	Avoid / exploit changes in risk	• Close areas of environment that are high risk fire areas / areas of high erosion • Incorporate opportunities to facilitated colonization in agri-environment schemes, flood defence schemes and coastal planning. • Raise profile of issue and implication to land managers to allow evolution of management (win win) • Exploit opportunities stemming from climate change e.g. grow exotic fora – not oaks • Agriculture land adaptation – have to adapt by Jan 2011 due to introduction of free 'derogation' markets (can't limit imports anymore) and see if subsidy regime can help promote change e.g. stewardship • Reducing run off, through use of contoured hedgerows and other buffer vegetation strips • Managed coastal retreat • Conserve genetic variation at local sites and increase species and habitat resilience through increasing the size, number and interconnectivity of sites.	• Adapt forestry to suit new migrating birds • New product market development to reflect changes (win win)	• Agriculture: new crops will need new infrastructure processing plants – and a new market. Can't talk about adapting agriculture without adapting the associated infrastructure. (Win win)

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The natural environment will be significantly affected by climate change. A lot of research has already been undertaken on this sector and in particular on agriculture. Habitats and natural resources are sensitive to climate and hence impacts have already been seen within this sector.

The Regis study looked at two regions, East Anglia and the Northwest in the UK to show what the future may look like under climate scenarios. The study concluded that climate change may have a noticeable impact at a regional level in the UK, but there is still uncertainty about the scale and nature of the impacts. Socio-economic developments are likely to have a major influence on the scale of these impacts.[80] This was particularly true when looking at agriculture. There is a similar situation on the Island, as climate will have an impact on agriculture, but other external influences will have a greater role to play.

This was also demonstrated in recent research[81], which showed that the vulnerability of both farmers and species is dependent on the climate scenario under consideration. Agriculture is particularly sensitive to scenarios of socio-economic change and these lead to different patterns of intensification, extensification and abandonment. 'Natural' species are more sensitive to climate change scenarios. In both cases, adaptation options and potential were strongly influenced by different socio-economic futures and policy intervention. The analysis shows how adaptation in the agricultural sector can influence the adaptation potential of natural species, highlighting the importance of cross-sectoral assessments and policy development.

Agriculture on the Island faces significant challenges in the future and there is an excellent occasion to incorporate climate change into policy development and to make the most of opportunities that may present themselves. Although agriculture may be able to quickly adapt by changing crops the supporting services and infrastructure may not be able to adapt as quickly. Water availability may become a problem in summer, particularly when there are competing needs between other sectors. Winter storage options may be a suitable solution to provide summer irrigation requirements.

The fisheries may be affected more so as changes in climate directly link to fish habitats. Warming sea temperatures may change the species of fish in the area. Reduced water and changing water quality in rivers may become a greater issue as species change. Controls may have to be implemented to protect habitats and species.

Forestry has already been affected by climate change extreme events with potential significant costs to this sector. (See technical report 5 on costs of extreme events). These extreme events are likely to increase in the future and forest management will be required to ensure damage is limited. A changing climate may 'squeeze' the pressure on the land for forests as changing climate may suit alternative species to grow or competition may occur from other sectors such as agriculture, tourism and pressures to release land for development.

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[80] Regional Climate Change Impact and Response Studies in East Anglia and North West England (RegIS) MAFF Project No. CC0337 May 2001 Soil Survey and Land Research Centre

[81] Berry, P.M., Rounsevell, M.D.A., Harrison, P.A. and Audsley, E., 2006. Assessing the vulnerability of agricultural land use and species to climate

Other pressures on the environment will increase through climate change. Increased visitor numbers may mean there is more footpath erosion, greater fire risk or even increased development as population grows. (This is discussed in the leisure and recreation section). A sustainable approach that is forward looking needs to be incorporated into biodiversity plans.

Examples of risk

- Lack of water for crops (grass, fodder, or cash) therefore affecting farming throughout the Island
- New pests, an increase in insects leading to an increase in disease risk
- Increased temperature stress on cold water fish species
- Increased housing needed for livestock
- Climate change will alter the probability of invasive and alien species establishing

Potential adaptation options

- Agricultural related infrastructure may need to evolve to match changes in land use
- Integrated land use and management strategies developed
- Better water resources planning; and information on 'best practice' techniques for soil conservation in a shortened cultivation window
- New crops will need new infrastructure processing plants – and possibly a new market.

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