Impacts of climate change on disadvantaged UK coastal communities

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This report explores the likely impacts of climate change on disadvantaged coastal communities in the UK.

The report is based on a qualitative study that aimed to explore the vulnerability of disadvantaged coastal communities to climate change. Coastal areas are likely to be more vulnerable to climate change than inland areas because, in addition to changes in flooding, temperature and precipitation, they will also be affected by a rise in sea level and wave heights and accelerated erosion. Disadvantaged communities in this context are described as those that are at risk of the physical impacts of climate change and which already suffer from high levels of deprivation or geographic isolation.

The research was undertaken through a literature review, an analysis of 'climate change hotspots' along the UK coastline, stakeholder interviews, focus groups, case studies with coastal communities and a national stakeholder workshop.

The report:

- identifies climate change hotspots in the UK coast;
- assesses differential social impacts of climate change in disadvantaged UK coastal communities;
- highlights barriers to climate change adaptation in UK coastal communities;
- provides recommendations for addressing some of the barriers identified.

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Contents

List of figures and tables

Figures

Tables

Executive summary

Background and context

This qualitative study aimed to explore the vulnerability of disadvantaged coastal communities to climate change. Coastal areas are likely to be more vulnerable to climate change than inland areas because, in addition to changes in flooding, temperature and precipitation, they will also be affected by a rise in sea level and wave heights and accelerated erosion. Disadvantaged communities in this context are described as those which are at risk of the physical impacts of climate change, and which already suffer from high levels of deprivation or geographic isolation.

The coast is defined for this research as 'the part of the land adjoining or near the sea' (*Oxford Dictionaries*) and coastal communities are those located near or surrounded by the sea or characterised by their proximity to it (e.g. seaside resorts, port and estuary towns and island communities). In this study, we refer to coastal communities as any local authority area that adjoins the sea and/or the coastline.

The UK has a long coastline relatively accessible to the UK population. The coast is the focus of important economic, environmental and social activities and sites. Some of the most important natural habitats and heritage sites are located on the coast. The coast also concentrates important economic activities from fishing to ports to offshore energy generation.

Many coastal communities also face a series of important socio-economic challenges including: ageing populations, youth outmigration and inward migration of older people, high proportions of retirees and people receiving benefits, transitory populations, physical isolation, poor-quality housing, an over-reliance on tourism, seasonal employment, low income and pressure on services during the summer months (CCA, 2010; CLG, 2007; Centre for Rural Economy, 2006).

The research

This study was undertaken to explore both actual and perceived vulnerability of individuals, social groupings and communities in UK coastal areas that are likely to be affected by climate change. The study also aimed to provide recommendations for improving coastal communities' adaptive capacity and resilience as part of climate adaptation responses. The study consists of four elements of research conducted between January and July 2010:

- A literature review and climate and coastal change hotspot analysis: the literature review covered existing knowledge of climate change impacts on the UK coast. The hotspot analysis drew on published data to provide an assessment of the likely impacts of climate change on the UK coast. This analysis focused particularly on sea level change, storminess, temperature and precipitation changes from the present to 2080, and the implications for coastal vulnerability.

- Stakeholder interviews: these were held with 25 national and local policy-makers from a range of agencies including government officials, local authorities and other agencies.

- Four case studies: these focused on coastal communities in Great Yarmouth, Skegness, Llanelli and Benbecula, where focus groups were run. The case studies aimed to explore

the understanding and perceptions of the impacts of climate change among local residents and service providers.

- A stakeholder workshop: this aimed to obtain feedback on the initial findings of the research.

Key findings

Climate change impacts on the coast

Climate change and sea level rise are likely to have a severe impact on UK coasts by 2080. The total rise in sea levels off the coasts of the UK may exceed 1 m and a rise of 2 m cannot be excluded. The frequency of storm events is expected to increase and, in combination with the rise in sea level, is expected to lead to an increase in flooding. Temperatures are expected to increase, particularly in the south and east of the UK. Winter precipitation is likely to increase markedly in northern and western areas of the UK. Erosion is also expected to increase, partly because of sea level rise. Parts of the coast that are composed of low-lying and soft sediment will be most vulnerable (e.g. in the east of England) because they are most easily eroded. The most exposed locations and estuaries may be particularly vulnerable.

Regional scale patterns of future sea level change around the UK were used to identify coastal hotspots vulnerable to climate change. A range of areas was identified where future sea level rise will be particularly rapid or have greatest impact because it will be combined with an increase in storminess and increased erosion. This initial analysis identified five main vulnerable areas along the UK coast: South Wales, Northwest Scotland, Yorkshire and Lincolnshire, East Anglia and the Thames Estuary. It should be noted that climate and coastal change impacts will be felt along the whole of the UK coast. The identification of 'hotspots' was undertaken mainly for the purposes of selecting case-study areas and providing a range of 'coastal and climate situations': that is, different types of impact ranging from erosion to flooding, in differing types of area from estuaries to ports and from rural to urban.

The impacts of sea level rise and storminess, together with terrestrial processes acting at the coast, present significant threats to coastal communities. These threats will be felt particularly keenly by communities that rely on the immediate coastal area for their residence, communications, and economic and social activity.

Social impacts of climate change on the coast

The social impacts literature suggests that climate change will affect people's health in particular, because of the effects of an increase in extreme events such as flooding and heatwaves. Those who have pre-existing health problems or are very elderly are likely to be worst affected. Mental health impacts are particularly prevalent among flood victims.

Extreme events associated with climate change (e.g. storms and flooding) are also likely to affect key public infrastructure such as health and emergency services and public transport along the coast. For coastal areas that are already isolated, impacts on transport and key infrastructure could be particularly serious.

The literature also suggests that climate change will impact coastal livelihoods, affecting in particular those depending on the coast for their economic activities (e.g. fishing and tourism). Climate change impacts can also lead to longer-term effects on neighbourhoods. For instance, areas that suffer the impacts of climate change or are considered to be at high risk may be affected by blight and a reduction in housing values, development and investment.

Case-study findings and implications for adaptation to climate change of coastal communities

Our case studies indicate that people's knowledge and awareness of climate change is often increased by having experienced recent severe events such as storms or flooding. Focus-group participants in areas where no recent events had been experienced were less likely to be aware of the risks of climate change for their areas. For those who were aware, the perception of climate change was often limited to one manifestation (e.g. flooding) and there was a lack of understanding of the range of impacts and the potential consequences for these communities.

Focus-group participants felt that the elderly would be the group most significantly affected by climate change impacts, yet local authority representatives and other interviewees felt that the elderly were less likely to be aware of the impacts of climate change than other groups. Respondents suggested that this was in some cases linked to a perception that climate change will not happen for another 20 or 50 years and therefore will not occur within an elderly person's lifetime. For many people, daily concerns such as low incomes or unemployment were seen as much more pressing issues posing more of a risk to their lives and well-being than climate change.

Our research suggests that coastal communities are likely to experience a series of challenges in relation to their ability to adapt to climate change. Residents may lack the economic resources to be able to make structural changes to their homes (e.g. to make them flood resilient) or may not wish or be able to afford to move away.

Coastal local authorities that contain areas of high deprivation may also be less likely to be able to afford or prioritise undertaking adaptation activities. In addition, local authorities in coastal areas may have other issues that need attention and funding, such as regeneration and housing needs, which means that there are limited resources to be spent on climate change adaptation.

The lack of effective communication of climate change impacts leads to low levels of awareness and understanding of the risk in communities and also low levels of preparedness for the impacts. However, paradoxically, authorities in the case-study locations also raised the issue that an increased understanding of the risk of flooding and erosion, which should be a positive thing in terms of aiding preparedness, could lead to 'blighting' of some areas. Once an area is identified as being at risk of flooding or erosion, land values can fall dramatically, resulting in residents being unable to sell their homes if they want to move. This is a particular problem for areas where there are no resources to provide or maintain flood and coastal defences.

There is an ever-increasing onus on communities to help themselves to be more resilient, but the way climate change is communicated (e.g. as a future risk), and the lack of clarity on actions needed, may be leading to apathy from local communities. It is likely that this is exacerbated by the range of day-to-day challenges that more disadvantaged residents in particular face, and by the fact that, in their view and comparatively, climate change is simply not a major issue. In addition, it is likely that self-protection actions at the household level would not be practical for extreme events such as tidal surges or severe storms.

Conclusion

Coastal areas of the UK may be severely affected by climate change in the future and some areas may already be at risk of extreme storms or flood events and the effects of sea level rise and coastal erosion. Climate change will pose risks and challenges both for people, including for their physical and mental health, and for coastal economies and local industry such as fisheries, agriculture and tourism. It may also affect people's access to, and the quality of, basic goods and services such as water, food, health and emergency care. The costs of emergency action, prevention and recovery may be a significant burden to coastal communities affected, with a large proportion of the costs often falling on local authorities in areas with already limited resources.

This research highlights that some coastal communities will also face significant challenges in achieving successful adaptation. Some of these communities are already disadvantaged (e.g. they are physically isolated or have high deprivation) which means they may find it difficult to prepare for the risks or respond to specific events. Climate change risks and impacts may also have knock-on effects such as residents of areas at risk being less able to obtain insurance.

The research also highlights a potential lack of adaptive capacity in agencies, which is likely to increase the vulnerability of disadvantaged coastal communities to climate change. Adaptation of coastal communities should be a key policy priority and it is likely to require several national and local policy areas to work together including regeneration, flood and coastal erosion management and emergency planning.

Our research illustrates that the coast is likely to suffer some of the worst impacts of climate change. In addition, some of the communities living along the coast of the UK can be considered particularly vulnerable to the future climate because of their socio-economic characteristics and their reduced ability to adapt. Although there are ongoing activities to increase awareness of flooding or improve flood warnings, our research has not uncovered any local or national policies or practices that currently provide a specific focus on reducing the vulnerability of disadvantaged coastal communities to climate change. This should be a policy priority and the vulnerability of these communities should be considered in the ongoing UK climate change risk assessment.

This research also points to the fact that the likely devolution of responsibility as a consequence of the localism agenda should be undertaken with care in relation to climate change adaptation. It is likely that many vulnerable coastal communities and the local authorities in which they live may need high levels of support from central government if they are to successfully adapt to a changing climate and reduce the risks from climate impacts.

Introduction

This report presents the findings of Scott Wilson's research project on the 'impacts of climate change on disadvantaged UK coastal communities'. The project was supported by the Joseph Rowntree Foundation (JRF) as part of its research programme on climate change and social justice.

Context for the research project

Coastal areas are likely to be more vulnerable to climate change than inland areas because, in addition to changes in flooding, temperature and precipitation, they will also be affected by a rise in sea level and wave heights. Both direct effects (such as accelerated coastal erosion and more powerful and frequent storm surges) and indirect effects (loss of critical physical infrastructure and coastal resources such as aquaculture, as well as declines in associated economic, ecological, cultural and subsistence values) will have physical and socio-economic impacts on coastal communities.

Coastal communities throughout the UK already face a variety of different complex issues which make planning for climate change particularly challenging. From a demographic perspective, the existing population of coastal communities is becoming increasingly older as a result of high levels of inward migration of older people and youth outmigration. From an economic perspective, coastal areas are often characterised by fragile economic conditions, including low incomes, high average unemployment rates, high numbers of people claiming incapacity benefit, seasonal employment (attracting transient populations) and pressure on services during the summer months due to tourism (Centre for Rural Economy, 2006).

Many parts of the UK coast are affected by high levels of multiple deprivation (see Figure 2 on page 14). For example, many coastal areas in England suffer from higher-than-average levels of deprivation related to income, employment and education, skills and training. This may be due to a number of factors, including the reliance on inherently low-skilled, low-paid industry sectors such as those related to tourism, which often also require part-time and seasonal workers. Seasonality of work also makes it difficult for workers to progress in terms of qualifications or career advancement, as each period of employment may be with a different employer. The physical isolation of many English seaside communities can also often act as a barrier to economic growth.

Higher-than-average deprivation in Welsh, Scottish and Northern Irish coastal areas can be identified in the data, but the correlation between coastal areas and high deprivation levels is less evident than in England. For example, in Wales several of the 20 per cent most deprived wards are located in and around Cardiff, with the remainder of highly deprived wards located directly on the (mostly northern) coastline. In Northern Ireland and Scotland, although high levels of deprivation can be found along the coast, highly deprived areas are more scattered throughout the country, in both urban and rural localities.

The physical risks of climate impacts, high levels of deprivation and the relative isolation of some coastal communities (e.g. some rural coastal areas or islands) mean that some coastal communities can be considered 'disadvantaged' and the vulnerabilities of these areas are the focus of this research. A recent research project (CAG Consultants, 2009) identifies those who are likely to be the most vulnerable to the impacts of climate change as:

- those living in places at risk;
- those who are already deprived;

- those who lack awareness of the risks of climate change, lack the capacity to adapt and are less well supported by family, friends and agencies.

Disadvantaged coastal communities clearly fit these three categories. Recent work undertaken for the Department for Environment, Food and Rural Affairs (DEFRA) on community adaptation to coastal change found that coastal communities generally have low awareness of the impacts of climate change and the implications for their lives and places (Fernández-Bilbao, *et al.*, 2009).

Aims of the research

The main aim of this research was to understand current and emerging climate change vulnerabilities specific to disadvantaged coastal communities and to make recommendations of how policy should respond to these challenges. We also aimed to make recommendations to improve coastal communities' ability to adapt to climate change.

Our research aimed to draw in a range of perspectives on the issues from communities and local and national stakeholders. It aimed to give a general overview rather than concentrating on a single sector. Our study set out to cover the whole of the UK.

The specific objectives of the research were to:

- identify 'hotspots' in terms of impacts of climate and coastal change across the UK;
- assess the likely climate change impacts on selected disadvantaged coastal communities, taking account of ongoing processes of change in coastal areas;
- identify the key characteristics that are likely to determine vulnerability to climate change in disadvantaged coastal communities;
- increase our understanding of coastal communities' perceptions and awareness of climate change impacts;
- synthesise knowledge on the inequitable distribution of climate change impacts, gaps in knowledge and barriers to addressing those gaps and actions;
- prepare recommendations for policy and practice in order to address the gaps and barriers identified through the research.

Report structure

This report includes the following sections:

- Section 1 presents background information on UK coastal communities and their vulnerability to climate change.
- Section 2 details the methodology and approach taken for the research.
- Section 3 assesses climate change and coastal change hotspots in the UK.
- Section 4 provides a review of existing research on the key differential social impacts likely to be experienced by UK coastal communities.

- Section 5 presents the findings of the four case studies undertaken as part of the project to explore community perspectives on climate change in coastal areas.

- Section 6 provides a discussion of the key findings and the implications for the adaptation of coastal communities.

- Section 7 presents the conclusions of the research.

1 Background to coastal communities in the UK

The coast is defined as 'the part of the land adjoining or near the sea' (*Oxford Dictionaries*). For the purpose of this research, coastal communities are those located near or surrounded by the sea or characterised by their proximity to it (e.g. seaside resorts, port and estuary towns and island communities).

The UK has a long coastline in comparison with its area. The length of the coastline is 12,500 km and the coast around mainland Britain is around 8,000 km, excluding all islands. Around 60 per cent of the coastline is located in Scotland and the offshore islands. The UK is also made up of over 1,000 islands (291 inhabited) and around 790 of these are located offshore from Scotland. The UK coast is also relatively accessible to all the UK population; the furthest place from the sea is about 117 km inland. The majority of the UK population visit the coast at least once a year (*UK Coast Guide*, n.d.).

Coastal areas in the UK are the focus of important economic, environmental and social activities (see Box 1 below).

Characteristics of disadvantaged coastal communities in the UK

Coastal communities are said to be among the least understood of Britain's communities. It has been highlighted that, comparatively, they have until now received very little attention either from policy-makers or the research community, particularly in comparison with rural and urban areas and declining industrial areas (Centre for Rural Economy, 2006).

The UK is dominated by a large coastline with a diverse range of coastal communities, including major urban and port areas such as Portsmouth or Cardiff, medium-sized resorts such as Skegness or Whitstable,

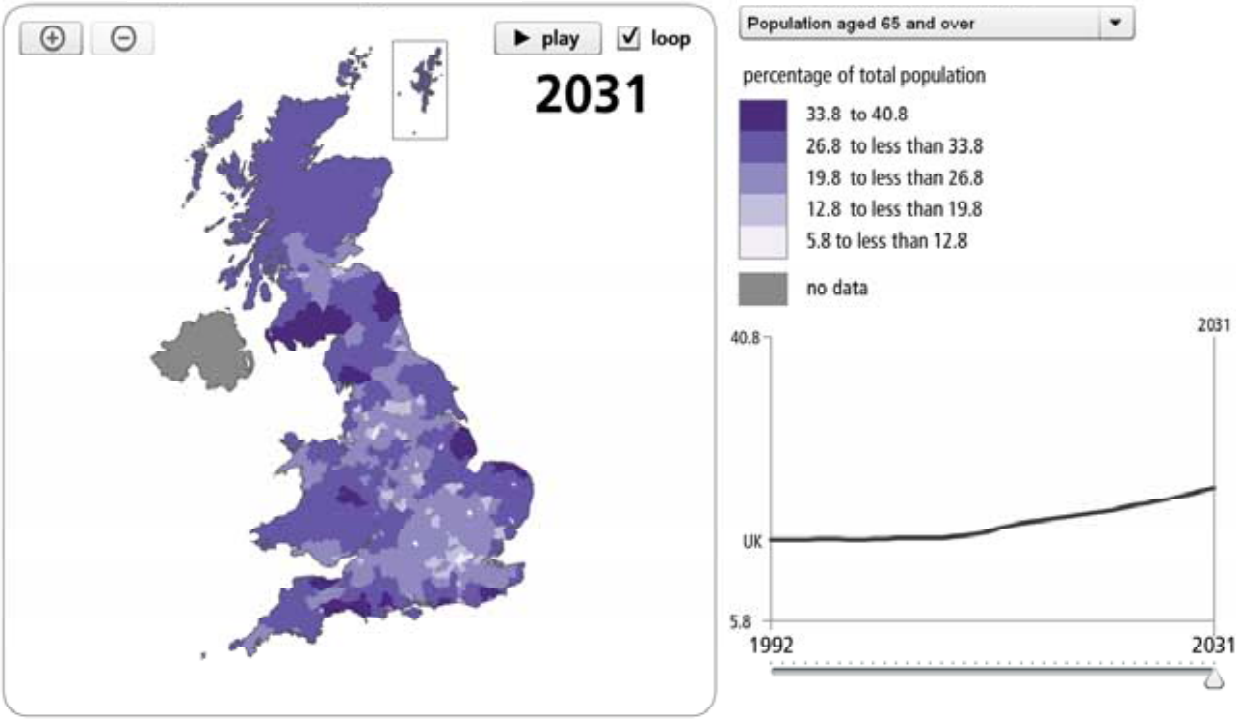
Box 1: UK coast facts

- Around 30 million people live in urban coastal areas.*
- Around 40 per cent of manufacturing industry is situated on or near the coast.
- Around 60 per cent of the best agricultural land is 5 m or less above sea level.
- Around 90 per cent of UK trade comes and goes through sea ports.
- Tourism based on coastal recreation is a significant contributor to local and regional economies.
- Coastal areas support a highly varied set of ecosystems including internationally significant wetlands and sites for major bird populations, and 10 per cent of notified nature reserves are located near the coast.
- Many parts of the UK coast are an important geological or cultural resource.

* Much of the coastline is also rural in nature with many dispersed settlements. However, there are no statistics on the numbers of people living in rural coastal areas in the UK.

Source: UKCP09

Figure 1: The ageing of the UK population, 1992–2031, categorised by local authority



Source: Office for National Statistics licensed under the Pan Government Agreement (screenshot from interactive map)

small rural settlements and islands such as the Hebrides or Orkney islands off Scotland. Coastal areas in the UK are rich in important natural habitats, heritage sites, tourism and recreational opportunities (e.g. walking, bird watching, sailing, angling) as well as economic activities ranging from port trade to fishing.

However, many coastal communities also face a series of signficant socio-economic challenges including ageing populations, youth outmigration and inward migration of older people, high proportions of retirees and people receiving benefits, transitory populations, physical isolation, poor-quality housing, an over-reliance on tourism, seasonal employment, low incomes and pressure on services during the summer months (CCA, 2010; CLG, 2007; Centre for Rural Economy, 2006). The magnitude of these traits varies between communities and in relation to coastal location within the UK. The extent of the ageing population of the coast, for example, can be seen in Figure 1 above, which shows the projected percentage of the population in each local authority that will be aged 65 and over by 2031. All but one of the British local authorities with the largest percentage of over-65s (34–41 per cent) are located on the coast.

Many coastal towns in the UK were once prosperous holiday resorts. However, with the introduction of cheap package holidays and flights since the 1970s, these towns have lost their pre-eminence as chosen holiday destinations and many have been in decline (see Box 2 on page 14). The 2007 *Index of Multiple Deprivation for England* shows that most coastal areas around the country experience higher-than-average deprivation. The *Coastal Regeneration Handbook* (CCA, 2010) highlights that if all coastal areas in England were to be 'rolled up' into a single region, the level of deprivation of this region would qualify the area for substantial EU and national regeneration funding. However, because of their size and location, many of the dispersed pockets of coastal deprivation fail to qualify for such support. Coastal deprivation in Scotland, Wales and Northern Ireland is more varied (see Figure 2 on page 15).

Vulnerability of coastal communities to climate change

Climate change is a global problem but the impacts will be experienced very differently in different areas and by different groups and communities. Ionescu, *et al.*, (2005) provide a useful explanation of the three reasons why this is the case, all of which affect the relative vulnerability of coastal communities:

Box 2: Deprivation in English coastal resorts

The 2010 *Coastal Regeneration Handbook* provides an indepth review of the complex socio-economic problems that are associated with English coastal resorts.

In England, coastal resorts are said to be in a 'seasonality – low wage – cheap housing – transience' cycle that is unique to resort deprivation and places high costs and burdens on coastal local authorities and other public service providers. For instance, the availability of cheap rental housing encourages a transient population with knock-on effects on local schools, where turnover of pupils can be 40 per cent in one year. High numbers of elderly people, teenage pregnancy levels, worklessness, high numbers of people receiving benefits and the influx of summer visitors can put a considerable strain on medical and public services. These demands can be compounded by the difficulty of recruiting public and private sector professionals in some coastal areas.

The location and lack of transport links, the lack of critical masses in customers, skills and business culture, and the lack of connections with the economies of larger towns can also defy efforts to diversify resort economies (CCA, 2010).

- First, climate change impacts are likely to be felt at the coast before they impact elsewhere inland because of increases in the frequency and seriousness of flooding, compounded by increasing coastal erosion and land instability (Fletcher and Potts, 2008). Impacts will also be felt differently in different coastal areas even within the UK. (We have looked at this variability of impacts for the UK's coast in Section 4.)

- Second, there will be differential impacts between regions and between groups in society. For instance, heavy rainfall can lead to flooding in some areas but not in others; heatwaves may be fatal for some elderly people but not affect others, and so on.

- Third, 'adaptive capacity' (the extent to which regions, communities, groups and individuals are able to prepare for, respond to and address the effects of climate change) is recognised as one of the key aspects that determine vulnerability.

Spickett, *et al.* (2008) describe vulnerability as a function of exposure, sensitivity and adaptive capacity. The *Climate Change 2007* report (IPCC, 2007) provides a similar definition:

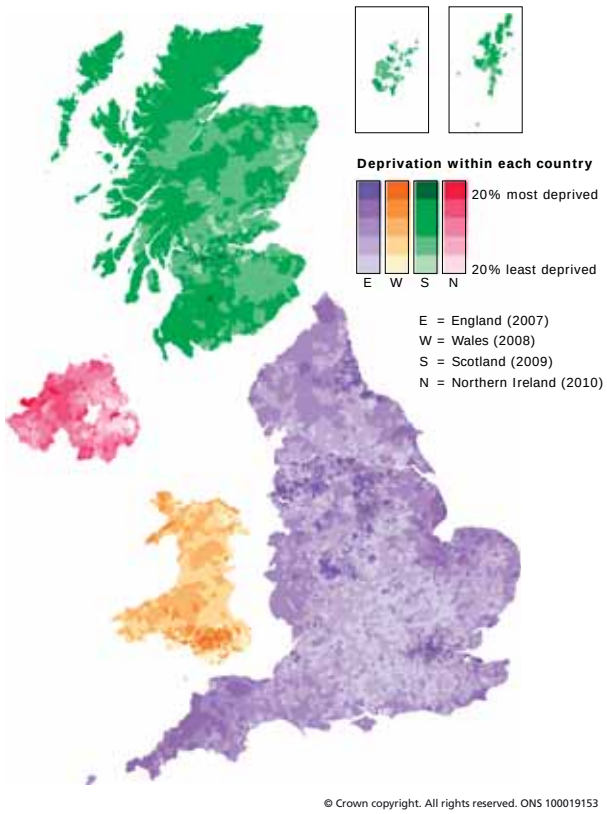
> *[Vulnerability is measured by] the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.*

Vulnerability is a contested concept. Practitioners seem to be moving on from talking about 'vulnerable groups' to seeing vulnerability as highly dependent on the context. For instance, while older people are often described as vulnerable, it is not their age that causes the vulnerability but the fact that they may have pre-existing health problems, or live in isolation or on a low income.

We also cannot generalise that all coastal communities in the UK will be equally vulnerable to climate change. What we can say is that the coastal impacts of climate change are likely to be significant (see Section 4) and that certain individuals, groups and communities within coastal areas may have a reduced capacity to adapt to some of these impacts (see Section 6).

In addition to being vulnerable to a changing climate, coastal communities, and particularly those most deprived, are already more exposed to certain risks. Walker, *et al.* (2006) found that while overall

Figure 2: Indices of multiple deprivation for each country in the UK



Source: Office for National Statistics licensed under the Pan Government Agreement

there is no link between deprivation and being disproportionately at risk of flooding (river and sea), there is a clear link between deprivation and tidal flood risk. People living in deprived areas were 62 per cent more likely than others to be at high risk of coastal flooding.

Key national coastal policies

The vulnerability of particular communities will also be affected by policy responses to climate change. In the last 50 years, the UK government's approach to defending the coastline from erosion and flooding has been through 'hold the line' policies and the use of 'hard' defences (e.g. sea walls and groynes). This has enabled economic and population growth in areas at risk. However, policy-makers have recently realised that maintaining this approach may not be cost-effective in the long term as sea level rises and erosion increases. In 2005, the government's 'Making Space for Water' (DEFRA, 2005a) programme represented a shift from hard defences and 'hold the line' policies to 'flood risk management'. MSFW recognises that flood and coastal erosion risk can be reduced but not eliminated. In addition, it introduces 'working with nature' processes such as 'managed re-alignment', which involves the deliberate breaching of defences (or not renewing defences when they reach the end of their expected life) in order to allow the coastline to move inland (Parliamentary Office of Science and Technology, 2009).

This new policy approach is reflected in the new round of Shoreline Management Plans (SMPs) introduced in England and Wales. SMPs are policy documents that translate national policy on flood and coastal erosion into policies for specific stretches of the coastline.[1] SMPs are informed by coastal processes, existing habitats that may need protection, and the presence of key infrastructure and settlements, and they set out policies for managing flood and coastal erosion risk. The first generation of SMPs reflected the historical defence practice. However, the second generation of SMPs (due to be completed by the end of 2010) follows the MSFW direction, resulting in some parts of the coast no longer

being defended. The new generation of SMPs is contentious within some communities (Parliamentary Office of Science and Technology, 2009). Indeed, several protest groups have formed along the coast in areas where defences will no longer be maintained. One such example is Happisburgh (North Norfolk) where a Coastal Concern Action Group has formed.

There is currently no statutory duty to provide flood and coastal defences, only 'permissive powers'[2] given to local authorities and government agencies to provide defences (e.g. the Environment Agency of England and Wales). This contrasts with the statutory obligation on national and local authorities and other agencies to protect European sites designated for their biodiversity interest. This creates debate in some coastal areas (sometimes known as 'birds versus people') as communities feel that they are not given the same level of protection as natural habitats.

National funding for flood and coastal defences in the UK is allocated through a cost benefit analysis process and takes account of population density. With a limited pot of funding, areas that are more prosperous and have higher property values, or those that have a larger population, are more likely to qualify for defences. In other words, cost benefit assessment helps ensure a system that is consistent across the country rather than being used to address welfare needs.

A recent policy development has put more focus on vulnerable communities in that DEFRA has introduced a new approach to prioritising flood and coastal defences. This system is based on five 'outcome measures' with associated targets that flood and coastal schemes will have to meet in order to be funded. One of these targets involves reducing the probability of flooding for the most deprived 20 per cent of areas. This approach was introduced in 2009–10 so it is still too early to assess the results of the change, but it shows that area-based deprivation is now a factor for policy funding decisions (Environment Agency, n.d.).

We conducted interviews with national policy stakeholders as preparation for our case studies. One of the questions asked was whether they could name any policies or initiatives related to climate change in coastal communities and targeted specifically at vulnerable people. There are several initiatives to improve flood warnings for vulnerable people, for instance through the use of flood wardens, and to increase flood awareness. Some respondents mentioned individual local projects that aim to increase awareness of the risks (e.g. flooding) and the DEFRA Coastal Change Pathfinders that target vulnerable coastal communities and aim to engage them in planning for adaptation. So while policy has not focused on social vulnerability, there may be scope through these initiatives for this to be picked up in local strategic planning. If vulnerability is to be more fully embedded in responses to climate change, however, more consideration of these issues may be needed in future national and local policy and practice.

The new emphasis on localism and communities taking action, introduced by the coalition government, is likely to lead to a progressive devolution of responsibility to local authorities and communities. It is also likely to put the onus on individuals and communities to increase their own resilience.

The Climate Change Act 2008 and the UK Climate Change Risk Assessment

The UK is the first country in the world to have introduced a legally binding framework to tackle climate change and its potential impacts. The Climate Change Act 2008 provides the legal framework to ensure the UK government meets its commitments in terms of both reducing greenhouse emissions and adapting to the impacts of climate change. The act requires the government to implement a National Adaptation Programme. This will be informed by an assessment of the risks posed to the UK by the climate up to the year 2100. The first UK Climate Change Risk Assessment (CCRA) is currently underway (H. R. Wallingford, 2010).

The first phase of the CCRA started in September 2009 and the complete risk assessment will be published in 2012. The first phase focused on developing the methodology for the assessment. The second phase of the project (due to be completed in autumn 2010) covers a UK-wide sector-based analysis across 11 sectors. Flood and coastal erosion is one of the sectors that are subject to analysis. A further analysis will then be undertaken of Scotland, Northern Ireland, Wales and at a sub-national level in England (H. R. Wallingford, 2010).

Climate change adaptation

There are two main responses to climate change: adaptation and mitigation. Mitigation focuses on reducing carbon emissions in order to avoid climate change (which is not a focus of this project, although it was mentioned by several participants particularly in the context of energy and fuel prices). Adaptation recognises that even if all emissions ceased today, a certain degree of climate change would still be expected and society needs to adapt to this. This report seeks to support coastal adaptation efforts. The European Commission defines climate change adaptation as 'taking action now so that we can be more resilient to our current climate, less susceptible to the impacts of future climate change and be in a position to take advantage of opportunities' (EC, n.d.).

This definition is notable because it highlights the need to increase resilience to our current climate as well as to future changes. The consequences of recent events, for instance the summer floods of 2007 in the UK, the heatwave across Europe in 2003 and extreme weather events experienced by some of our case-study locations (see Section 6) show that we are indeed ill-prepared for extreme weather events that affect our communities now.

Adaptation is essential in order to prepare for future risks, which are likely to be exacerbated by global warming. In addition, adequate adaptation could enable communities to benefit from potential opportunities that a changing climate can bring. For instance, changes in land and water temperature could extend the range of crops that can be grown in some areas or increase the availability of certain fish or shellfish species along our coast.

Regarding what constitutes 'adaptation', the UK Climate Impacts Programme (UKCIPb, n.d.) highlights that adaptation activities can cover measures and strategies that contribute to one of two things:

- building adaptive capacity – including creating the information (research, data collecting and monitoring, awareness raising), supportive social structures (organisational development, working in partnership, institutions) and supportive governance (regulations, legislations, guidance) that are needed as a foundation for delivering adaptation actions;

- delivering adaptation actions – actions that help to exploit opportunities or reduce vulnerability to climate risks.

The two types of adaptation activities could be considered a two-step approach: adaptive capacity is needed in order to adequately plan and deliver adaptation actions. Adaptation also covers a range of practices including:

- changes in behaviour;

- structural changes;

- policy-based responses;

- technological responses;

- managerial responses.

(Food and Agriculture Organization, n.d.)

This project sets out to inform adaptation to climate change in UK coastal areas by examining the risks and vulnerabilities of disadvantaged coastal communities and the awareness and perceptions of the problem in selected areas in order to support developing national and local policy and practice responses.

2 Methodology and approach

This study was undertaken to explore both actual and perceived vulnerability of individuals, social groupings and communities in UK coastal areas that are likely to be affected by climate change. The study also aimed to provide recommendations for improving coastal communities' adaptive capacity and resilience. The study consists of four elements of research conducted between January and July 2010:

- a literature review and climate and coastal change hotspot analysis;
- stakeholder interviews;
- four case studies;
- a stakeholder workshop.

Literature review and hotspot analysis

To inform our interviews and case studies, we conducted an initial literature review on the social impacts of climate change with a focus on the UK coast. Our review included reports from the Intergovernmental Panel on Climate Change (IPCC), the Environment Agency, the Scottish Environment Protection Agency (SEPA) and the Department for Environment, Food and Rural Affairs (DEFRA) as well as academic papers.

To identify those coastal areas in the UK that are likely to be worst affected by the impacts of climate change and coastal change, additional research was undertaken by David Smith and Jasper Knight from Climate Change Risk Management (CCRM). The research considered the role of sea level change, storminess, temperature and precipitation changes in the UK from the present to 2080, and their implications for coastal vulnerability.

Stakeholder interviews

In total, 25 interviews were conducted with key national, sub-national and local stakeholders to address the research objectives outlined in Section 1 of this report. The interviews were designed to examine in greater detail the findings from the literature review and to supplement and validate them.

The project team developed a questionnaire to ascertain interviewees' awareness and perceptions of:

- key climate change impacts and likely affected geographical areas;
- differential climate change impacts on various groups/sections of society and community;
- climate change impacts on disadvantaged coastal communities specifically;
- adequacy of plans, policies, regulations or procedures to reduce impacts on disadvantaged coastal communities;

- recommendations for adaptation to climate change impacts on the coast.

The choice of interviewees was based on our need to:

- obtain a balanced representation of views across organisations, professional backgrounds and geography (considering the project's UK-wide focus) from people with knowledge of climate change impacts;

- provide additional evidence and research for case-study selection.

Stakeholders included representatives from the Department for Communities and Local Government (DCLG), the Environment Agency, Natural England, the Welsh Local Government Association, Scottish Centre for Regeneration, Health Protection Agency (HPA), Lincolnshire County Council, British Resorts and Destinations Association (BRADA), Age Concern Scotland, Shelter England, Standing Conference on Problems Affecting the Coastline (SCOPAC), East of England Ambulance NHS Trust, and the Royal Town Planning Institute.

Case studies

The research on climate and coastal change hotspots identified five coastal areas where the combined impacts of climate and coastal change are likely to be particularly severe:

- Yorkshire and Lincolnshire;

- East Anglia;

- the Thames Estuary;

- South Wales;

- Northwest Scotland.

Four case-study locations were chosen, based on the hotspot analysis for fieldwork and on the need to ensure that a range of 'coastal situations' was represented. These were:

- Great Yarmouth, East England: an urban port;

- Skegness, East England: a rural area;

- Llanelli, South Wales: an estuarine area;

- Balivanich, Benbecula Island in the Outer Hebrides, Scotland: an island and fishing community.

The case studies were exploratory and designed to:

- increase our understanding of coastal communities' perceptions and awareness of climate change impacts, particularly indirect impacts;

- find out how local authorities, the voluntary sector and other organisations working in the case-study locations understand and are preparing for climate change impacts;

- identify any ongoing activities that aim to increase community awareness and/or adapt to climate change in these areas;

- identify any potential barriers to adaptation in the case-study areas.

The case studies involved one or two focus groups of ten residents and business representatives from each case-study site, each of which lasted approximately one hour. Targeted recruitment of people from various ages and socio-economic backgrounds was carried out to ensure that a range of perspectives was obtained from residents across the sites. In Great Yarmouth we conducted a focus group with young people aged 18–29, including people who were not in education, training or employment (NEET), people receiving benefits and part-time employed, men and women. For the Skegness focus group, the criteria for participation included retirees aged 55+, both men and women. The Llanelli focus group included working-age adults aged 24+ who were long-term residents, and also both men and women. Given that climate change will have particular implications for people living in caravan parks, as well as people who live in temporary accommodation but on a permanent basis along the coast, we attempted to recruit caravan and holiday residence dwellers for a fourth focus group in Great Yarmouth. However, despite extensive recruiting efforts, we were not able to recruit a sufficient number of participants.

In each case-study location, a number of face-to-face interviews and meetings were conducted with local residents, public officials including local authority staff (planners, emergency services, environmental officers), representatives from other national agencies (e.g. Scottish Natural Heritage) and business owners to supplement the focus group findings. Case-study findings are presented in detail in Section 6.

Workshop

On 10 June 2010, a stakeholder workshop was held to facilitate interdisciplinary conversations among diverse experts including academics, policy officials from central government (DEFRA, DCLG, the Environment Agency), local authority representatives and the research community. The workshop was a forum in which to present and discuss our findings on the differential social impacts of (physical) climate change likely to affect coastal communities along the UK coast and related examples of adaptations and practice in coastal areas. It was also an opportunity to identify and highlight any existing policy and practice gaps, and pool suggestions for successful climate change adaptation. The findings that emerged from the workshop were used to inform this final report.

Research scope, gaps and limitations

The research considered climate change impacts likely to have the most significant impacts on UK coastal communities, including coastal erosion, sea level rise, storminess, temperature increases, and changes in precipitation. Other climate change impacts that may have implications for the UK as a whole were not assessed.

As noted above, there were limitations in the resident engagement in Great Yarmouth. The research would have also benefited from further input from social policy representatives of UK government bodies, voluntary organisations and civil society, where only limited input was obtained despite the efforts of the research team. This could be a reflection of the fact that adapting to climate change is the policy responsibility of 'environmental' government departments such as DEFRA or SEPA, and other organisations may not see this agenda as part of their remit of interest. It could also be a reflection of the fact that climate change adaptation is a relatively new area of research and policy in the UK.

In general, this study aimed to explore a range of issues in relation to climate change impacts on coastal communities. It is a small study with short timescales so the main aim was not to provide all the answers in relation to this area of research but to highlight potential issues. Some of these issues could be explored in more detail in future research.

3 Climate change impacts on the UK coast

This section presents a summary of the findings of the research on coastal and climate 'hotspots' undertaken by CCRM for this project. The analysis considers the changing coastal picture and the role of sea level, storminess, temperature and precipitation changes in the UK from the present to 2080, and their implications for coastal vulnerability. The analysis aided in the selection of our case-study locations.

Methodology

The analysis used regional scale patterns of future sea level change around the UK to identify coastal hotspots vulnerable to climate change. A range of areas was identified where future sea level rise will be particularly rapid or have greatest impact because it will be combined with an increase in storminess and therefore increased erosion. This initial analysis identified five main vulnerable areas along the UK coast: South Wales, Northwest Scotland, Yorkshire and Lincolnshire, East Anglia and the Thames Estuary.

These hotspots were then examined in detail with respect to present and future climate change. The future climate changes discussed here refer to UKCP09's medium (A1B) emissions scenarios for the decades 2020s, 2050s and 2080s. The low (B1) and high (A1FI) scenarios show the same directions of change in temperature and precipitation, but of differing magnitudes. The difference in precipitation and temperature predicted from low and high emissions scenarios also increases over time from the present to the 2080s. The magnitude of change will have a minor, localised effect on coastal processes and properties, but is not expected to affect the general regional impacts on the coastal hotspots discussed in this report. The scenario used, however, shows some significant differences with respect to sea level rise. These factors are discussed in detail below.

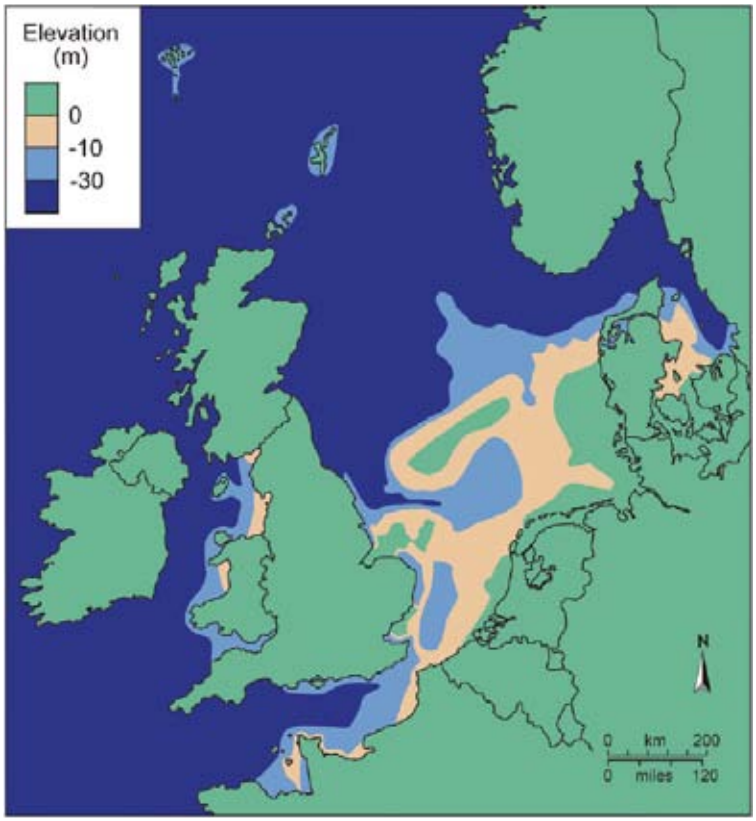
The report also considered the geological (composition and dynamics that affect rocks) and geomorphological (characteristics and development of landforms) aspects of the UK's coastline. The impacts of changes in climate will be very diverse at the local scale, and will be strongly determined by local-scale topography, geology, land surface processes (including river dynamics and land movement processes) and the capacity of human systems to manage or adapt to change effectively.

The remainder of this section summarises the key findings of the analysis and the implications for coastal vulnerability. This section also summarises the key likely climate and coastal change impacts that will affect the five hotspots. It should be noted that climate and coastal change impacts will be felt along the *whole* of the UK coast. The identification of hotspots was undertaken mainly for the purposes of selecting case-study areas and providing a range of 'coastal and climate situations', that is, different types of impact ranging from erosion to flooding, in differing types of area from estuaries to ports and from rural to urban.

Evolution of the present-day coastline of the UK

The islands of the UK lie on the edge of the continental shelf off Northwest Europe and comprise rocks representing all geological periods from gneisses of the Archaean Period (over 2,700 million years old) in the Northwest, to rocks of the Palaeogene and Neogene Periods (dating from 2 million to 63 million years ago) in the Southeast. Throughout the millennia of its complex and varied tectonic and climatic/environmental history, the area underwent major changes. Most significantly, a series of glaciations occurred over the last 2 million years, and it is these, combined with the underlying solid geology, which have resulted in the

Figure 3: The coastlines off Northwest Europe 7,500 years ago



Source: Shennan, *et al.* 2000

present-day coastal landscape. These have also given rise to the very varied physical nature of the UK coast.

The repeated glaciations of the last geological period, the Quaternary, had two major effects. First they deeply eroded the pre-existing landscape, mainly in upland areas of the UK, which were ice source areas and deposited considerable amounts of sediment mainly in lowland and southernmost areas of the UK. Secondly, they caused the land to be alternately depressed (beneath the weight of the ice) then raised (as the ice melted). Along with changing sea levels offshore, this resulted in a changing coastal landscape. The changes of sea level at the coast are known as 'relative sea level changes' to distinguish them from the changes in the sea surface itself. Across the UK, the pattern of recovery from the ice loading varied.

Around the coasts of the UK, the rising sea levels encountered a land surface still recovering from the weight of the ice, so that the progress of coastal change was complex. The changing coastline of Northwest Europe during this period is a good example of this (see Figure 3 above). There was probably a connection between the North Sea and the Channel at this time (the map is too generalised to show this).

By about 2,000 years ago, sea levels around the coasts of the UK had reached close to present-day levels, and since then there has been gradual coastal change as the processes of erosion and deposition have acted upon the solid rocks and unconsolidated glacial and other sediments, while sea levels and storminess patterns have changed.

Coastal changes

At present, it has been estimated that some 17% of the coastline in the UK as a whole is suffering from erosion, with 30% in England, 23% in Wales, 20% in Northern Ireland and 7% in Scotland affected. However, erosion varies greatly between different coastal areas because of differences in geology and geomorphic processes acting upon them.

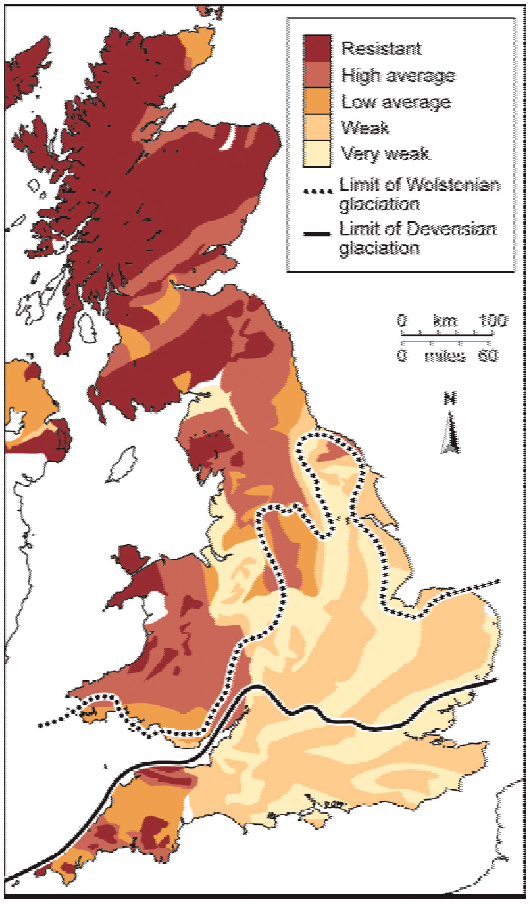
Coastal erosion

The geology of the UK is important in considering the potential effects of coastal erosion. The older and more resistant rocks are located in Northwest England, Wales, Scotland and Northern Ireland. The coastlines of these areas are therefore the most resistant to erosion. Younger sedimentary rocks are less resistant, and areas of glacial sediments are particularly prone to erosion. These areas include the east, southeast and south of England.

Figure 4 (below) is a map of the relative resistance of rocks in the UK, produced by Clayton and Shamoon (1998). This map is derived from a digital database which contains data on altitude and geology by National Grid kilometre squares. Here, the 71 most common rocks were analysed in terms of the degree to which they form high ground. This was then used as an indicator of their resistance. Clayton and Shamoon did not include the westernmost parts of the Outer Hebrides and Northern Ireland, but it can be seen from a comparison of the geology in Figure 4 that the resistance of the rocks in the missing areas is similar to those in the adjacent areas on the map produced. It shows that the most easily eroded coastlines, whether of glacial sediments or of younger rocks, lie in the east, southeast and south of the UK.

Geomorphic processes (changes to the shape or form of the land) may result from marine and terrestrial activity, or a combination of both. Marine activity includes sea level rise, which, particularly in combination with storminess, will result in erosion, especially in coastlines where the geology is of less resistant rocks and sediments. Terrestrial processes in periods of dry weather include desiccation, gullying and subsidence, which all render coastal areas more susceptible to erosion. In periods of storminess and increased run-off, ground-water tables will rise and sediments will be destabilised. In some particularly vulnerable areas, this can lead to landslipping which in turn can also accelerate erosion. Areas prone to landslipping include parts of Yorkshire and East Anglia and the south coast.

Figure 4: The relative resistance of rocks of the UK and the limits of glaciation



Source: Clayton and Shamoon, 1998

A particular factor affecting coastal erosion is the integrity of the beach, which may act to dissipate wave energy. It has been observed that beach profiles are steepening in many areas, reducing the ability of the beach to reduce the impact of waves. This may be due to the increased effects of storms, since it is well known that storms generally comb sediment out to sea, removing it from the foreshore. However, human activity may also be a factor (i.e. the removal of sand from the beach for construction).

Current and future sea level rise

The mean level of the sea surface (as opposed to the sea level at the coast) around the UK is rising, as elsewhere in the world. IPCC (2007) estimates that the total rise in the mean global sea surface in 2090–9 relative to 1980–99 will range between 0.18 and 0.59 m (see Table 1 below). However, UKCP09 draws attention to the fact that these figures do not take account of recent knowledge of the behaviour of the Greenland and Antarctic ice sheets. It seems very likely that the rise will exceed 1 m and in all probability will reach 1.5 m (Rahmsdorf, 2007). Some scientists (e.g. Hansen, 2007) suggest 2 m. Hence the published estimates of both the rate and the total rise are likely to be conservative.

The picture across the UK varies. In an analysis of key ports (see Figure 5 on page 25) only Lerwick, Malin Head, Rosyth and Belfast Harbour show the land rising against the sea, but the latest analysis (see Figure 6 on page 25) suggests that Wick, Aberdeen, Dunbar, Portpatrick, North Shields, Heysham, Liverpool and Dun Laoghaire in addition to Malin Head, Rosyth and Belfast Harbour should show a fall in sea level against the land, while Lerwick should not. This demonstrates the uncertainty surrounding present tidal data.

Shennan, *et al.*, (2009) have recently mapped probable relative sea level change in the UK taking place at the present time (see Figure 6), based upon a glacial isostatic adjustment (rise of landmasses that were depressed under large sheets of ice) model. They show the expected pattern: to the North and West, most land areas are rising relative to the sea surface (with the exception of the Shetland Islands), while to the East, Southeast, South and Southwest, relative sea levels are rising.

Storminess

Storms play a considerable role in coastal change. Combined with a rising relative sea level they are likely to become of increasing significance in coastal erosion and thus in coastal retreat. Dawson, *et al.* (2003, 2004) note that since the medieval period there has been a sustained increase in winter storminess in the North Atlantic. Wave heights have also been increasing in the North Atlantic (Alexandersson, *et al.*, 1995).

Table 1: Projected mean global total sea level rise at the end of the 21st century

Modelled scenario	Range in metres
B1	0.18–0.38
A1T	0.20–0.45
B2	0.20–0.43
A1B	0.21–0.48
A2	0.23–0.51
A1F1	0.25–0.59
Range of all scenarios	0.18–0.59

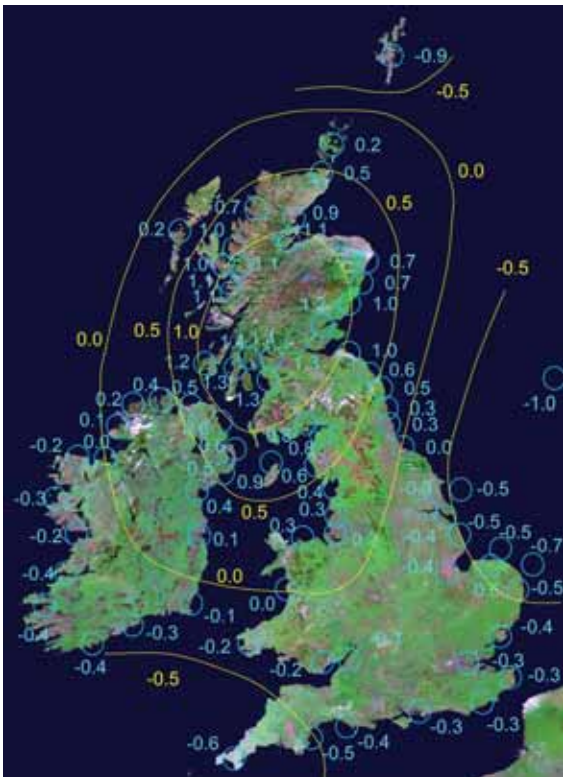
Source: IPCC, 2007

Figure 5: Mean sea level trends from tidal stations with more than 15 years of records for the UK in mm/year

A Aberdeen, **BH** Belfast Harbour, **D** Dunbar, **DE** Devonport, **DO** Douglas, **DOV** Dover, **DU** Dun Laoghaire, **H** Holyhead, **HE** Heysham, **I** Immingham, **L** Liverpool, **LE** Lerwick, **LO** Lowestoft, **MH** Malin Head, **N** Newlyn, **NS** North Shields, **P** Portsmouth, **PO** Portpatrick, **R** Rosyth, **S** Sheerness, **SO** Southend, **T** Tilbury, **W** Wick; records for stations underlined are regarded as questionable

Source: Woodworth, *et al.* 1999, 2009

Figure 6: Current rate of relative land and sea level change in the UK and the Irish Republic, showing relative land uplift as positive and relative subsidence as negative



Source: Shennan, *et al.* 2009

It is, however, uncertain whether developing storminess reflect changes in greenhouse gas emissions (Osborn, 2004). Nevertheless, there appears to be an increase in intense cyclones, although no shift in the pattern of storm tracks. In detail, the northern UK has seen a decrease in the number of severe storms in recent years, while the central and southern UK has seen an increase (Allan, 2006).

Increase in temperature

The UK has experienced significant warming throughout the twentieth century and particularly during the last few decades. This warming has been more significant during winter and in the south and east of England, with least warming in Scotland and Northern Ireland. Maximum temperatures have also increased more than minimum temperatures, particularly in central and eastern England where decreased summer precipitation has occurred (Croxton, *et al.*, 2006).

The future predicted increase in summer and winter temperatures under the medium emissions scenario and at the three time slices proposed by UKCP09 (2020, 2050 and 2080) are shown in Table 2 below. The predictions show that temperatures will continue to rise over the period up to 2080 by up to 3–4 degrees Celsius.

The changes in temperature across the UK have implications for coastal weathering and erosion processes. Increased summer temperatures and decreased humidity will lead to increased desiccation and salt weathering of coastal rock platforms and within the intertidal zone, and increased biological weathering in these environments (Thompson, *et al.*, 2002). This will particularly affect northern and western UK coasts

Table 2: Timeline of future impacts based on the medium emissions scenario

Decade	Temperature change (°C) relative to 1961–90 baseline (range of changes refers to the different UK regions identified by UKCP09)	Precipitation change (%) relative to 1961–90 baseline (range of changes refers to the different UK regions identified by UKCP09)	Sea level rise (cm) relative to 1990 baseline (range of changes from 4 UK cities identified by UKCP09)	Cumulative coastal impacts
2020s	+1.1 to +1.3 (winter) +1.3 to +1.6 (summer)	+4 to +7 (winter) –4 to –9 (summer)	+5.7 to +9.7	• Increasing frequency of storm surges and lowland floods • Increasing erosion on sandy coasts
2050s	+1.6 to +2.2 (winter) +2.0 to +2.8 (summer)	+9 to +17 (winter) –11 to –23 (summer)	+13.9 to +21.8	• Significant impacts of sea level rise in estuaries • Increasing landslide frequency in many areas
2080s	+2.2 to +3.0 (winter) +3.0 to +3.9 (summer)	+11 to +23 (winter) –12 to –28 (summer)	+24.4 to +36.3	• Significant changes in sediment supply along sandy coasts • Widespread erosional impacts in all areas

Source: UKCP09

where rockiness is more common. Increased winter temperatures will lead to decreased frequency and intensity of frost weathering within rocky cliffs and uppermost parts of rock platforms.

Changes in precipitation

Changes in precipitation have been more variable than those of temperature but an increase in total precipitation can be observed in the UK. Significant increases have been observed over the northwestern parts of the UK. Summers have become drier in most places, relative to the 1960s–90s baseline, and summer precipitation is most reduced in London and Southeast England.

Predictions suggest that winter precipitation is likely to continue increasing by up to 23 per cent by 2080, and summer precipitation will continue to decrease during the same period by up to 28 per cent (see Table 2 on page 26).

Changes in precipitation across the UK are significant for the coastal zone. Decreased summer precipitation (and increased temperatures) will lead to increased desiccation particularly in loose sediments with high pore water content, which are located mainly in lowland areas of glacial sediments in the northeast and east of England, East Anglia, and some areas of Northwest England such as Lancashire. This has the effect of causing desiccation cracks to form, thereby structurally weakening cliffs. This process will also affect coasts in southern England, including much of the coast from Dorset to Essex (Dornbusch, *et al.*, 2008).

Increased winter precipitation volumes and increased precipitation intensity have greatest impact in the northwest of the UK, causing increased frequency and magnitude of coastal landslides, debris flows and mud flows that are generated when steep coastal slopes become saturated and unstable (Knight, 2005).

Other factors

Other factors that will affect the coastline include wind speed changes and more frequent extreme events.

Wind speed changes

Wind speed changes are significant for coastal regions because they are related to the height of wave-generated nearshore winds. Increased wind speed (in an onshore direction) can lead to increased wave height and storm surges. Models suggest northern Europe will experience an increase of up to 8 per cent in mean wind speed, particularly during the winter/spring period when atmospheric pressure gradients are steepest. This has implications for the intensity of winter storms that are associated with periods of greatest coastal erosion on Atlantic coasts. Relative humidity changes are related explicitly to temperature and precipitation together. Across the UK, there is a significant decrease in relative humidity in summer everywhere except for Northern Ireland.

Extreme events

Extreme heatwaves/droughts

Restricted plant growth and wildfires during drought conditions, along with very low water content, weaken the soil structure and make it more susceptible to wind erosion and mass failure by cliff collapse. Heatwaves and droughts therefore have great potential to destabilise coastal environments, particularly along coastlines comprised of loose glacial sediments or sand and gravel. Very warm shallow-water temperatures can lead to water stratification, low dissolved oxygen content, and widespread fish death. Toxic algal blooms are also common.

Extreme precipitation events

Very high-magnitude rainfall leads to flash floods, which occur most often in the UK during winter (intense cyclones) and summer (thunderstorms) (Alexander and Jones, 2001). Coastal river valleys experience

Table 3: Summary of climate change hotspots analysis

Hotspot	Summary
South Wales	• Rocky coasts are at risk of cliff collapse by desiccation, wetting, wave undercutting. • Port, petrochemical, harbour facilities are vulnerable to storm waves, erosion, sedimentation. • Erosion, sedimentation in estuaries. • Erosion of mudflats and saltmarsh. • Effects on reclaimed industrial sites.
Northwest Scotland	• Increases in winter precipitation will affect weathering and erosion of cliffs and increase cliff collapse in addition to wave undercutting. • Cliff collapse may cause rock falls or landslides and debris flows. • Sandy beaches, sand dunes, sand bars and estuaries may be destabilised by changes in sedimentation, and longshore drift[3] shifting sand bars will make access to and from small island harbours uncertain, affecting isolated communities. • Increased wave intensity will impact fishing, oil rigs and offshore wind farms.
Yorkshire and Lincolnshire	• Weakening and collapse of cliffs due to desiccation as a result of higher summer temperatures and lower precipitation; also cliff destabilisation as a result of decreasing vegetation cover. • Weakening and collapse of cliffs due to increased precipitation in winter, which causes more water to penetrate into desiccated cracks. • Higher rates of coastal erosion from higher sea levels, more frequent storm surges and weakened cliffs.
East Anglia	• Weakening and collapse of cliffs due to desiccation as a result of higher summer temperatures and lower precipitation; also cliff destabilisation as a result of decreasing vegetation cover. • Weakening and collapse of cliffs due to increased precipitation in winter, which causes more water to penetrate into desiccated cracks. • Higher rates of coastal erosion from higher sea levels, more frequent storm surges and weakened cliffs. • High erosion will cause enhanced rates of longshore drift which may pose threats to the major ports of Great Yarmouth, Felixstowe and Harwich.
Thames Estuary	• Higher rates of erosion can be anticipated around the outer margins of the Thames Estuary. • Rising sea level is a major threat to the city of London and to low-lying areas in the Thames Gateway region. • Enhanced erosion coupled with sea level rise is likely to lead to a redistribution of sediment, with more inland ports such as Rochester and Chatham experiencing access difficulties.

significant flood impacts during these events, and associated hazards with debris flow and mud flow. These changes can lead to significant remodification of fronting beaches. High rainfall events more widely also destabilise steep cliffs and are therefore associated with landslide activity.

Climate and coastal change hotspots

Overall, the analysis of climate and coastal change highlights five main vulnerable areas along the UK coast: South Wales, Northwest Scotland, Yorkshire and Lincolnshire, East Anglia and the Thames Estuary. Table 3 (on page 28) presents a summary of the main likely impacts of climate change on those areas.

Summary

The key findings of this section can be summarised as follows:

- The total rise in relative sea levels off the coasts of the UK by 2100 may well exceed 1 m; they could easily reach 1.5 m, and a rise of 2 m cannot be excluded.

- There is no clear evidence for an increase in the total number of storms, but the number of intense storms may increase.

- Temperature and precipitation changes show consistent directions of change in different regions of the UK, with warming occurring most markedly in the south and east of the UK. Northern and western areas show a marked increase in winter precipitation.

- Future temperature and precipitation patterns are largely insensitive to the UKCIP future emissions scenario that is used, whereas sea level trend is very sensitive. These factors in combination, however, should be used to consider overall coastal sensitivity to change, not just sea level rise.

- Low-lying and soft-sediment coasts are more easily eroded and are sensitive to sea level rise. In these areas, the more exposed locations and possibly some estuary areas may be particularly vulnerable.

- Estuarine areas will be particularly vulnerable since sea level rise may increase tidal range, while storminess may result in a funnelling of storm surges in these areas.

- Coastal change impacts tend to be localised in nature and strongly reflect local geologic patterns. They are also very strongly influenced by processes that occur over short timescales such as episodic storms.

- The impacts of sea level rise and storminess, together with terrestrial processes acting at the coast, present significant threats to coastal communities. These threats will be felt particularly keenly by communities that rely on the immediate coastal area for their residence, communications, and economic and social activity.

4 Differential social impacts of climate change in UK coastal communities

The social impacts of climate change have until recently been overshadowed by scientific debates and economic questions about climate change. There is, however, an emerging body of literature that deals with the possible social effects of climate change and addresses the sometimes unquantifiable risks to people's health, economic livelihoods and access to services, and to particular population groups, and highlights how climate change is contributing to increasing social vulnerability (CAG Consultants, 2009). However, there is at present little research on the potential social impacts of climate change in UK coastal communities specifically, or how these impacts may be experienced differentially by specific individuals, social groupings and communities residing in these areas.

The International Association for Impact Assessment (IAIA) defines social impacts as 'all impacts on humans and on all the ways in which people and communities interact with their socio-cultural, economic and biophysical surroundings' (IAIA [online]). Recognising that the severity of these social impacts is also experienced differently depending on people's exposure and sensitivity to the climate change impact (Spickett, *et al.*, 2008), the focus here on examining 'differential social impacts' aims to provide a more concrete understanding of how climate change will affect the most vulnerable people who live on the UK coast.

This section of the report highlights the differential social impacts from climate change that coastal communities may experience in the short to medium term. It draws on a growing body of literature which examines the social distribution of climate change effects in the UK and considers in particular why these might be significant in coastal areas.

Health and well-being

Climate change will have significant effects on people's health across the UK. According to the Department of Health report *Health Effects of Climate Change in the UK* (2001/2) and the follow-up report published jointly by the Department of Health and the Health Protection Agency (DoH and HPA, 2008), the health effects of climate change will pose significant challenges for public health authorities who will need to plan for likely impacts (see Table 4 on page 31).

The literature suggests that when it comes to ascertaining the health and well-being impacts of climate change in coastal areas, coastal communities face dual challenges. On the one hand, there is a perceived positive quality of life and health associated with coastal living. On the other hand, UK coastal communities tend to have a large number of at-risk groups[4] and appear to have a disproportionately high number of people claiming sickness and disability benefits (CLG, 2007). People with existing poor physical and mental health are more likely to be sensitive to the impacts of climate change (CAG Consultants, 2009) and existing poor health among some coastal populations may increase the health effects of certain impacts such as flooding, which may worsen from climate change (Fernández-Bilbao, *et al.*, 2009). This is likely to place a strain on the existing health and social services infrastructure in already disadvantaged coastal areas.

Sea level rise and tidal surge flooding pose significant health risks, particularly to coastal lowlands such as Norfolk, Suffolk and the Humber and to other coastal areas with high flood risk and poor coastal defences. The evidence tells us that despite the high risk, deaths associated with flooding are rare. According to a Department of Health report published in 2008, there have been eight deaths reported since 2001 –

Table 4: Summary of the health effects of climate change in the UK

Health effect	Likely impact
Temperature-related illness and death	Cold-related deaths are likely to decline substantially by approx. 20,000 cases per year. Heat-related deaths are likely to increase by about 2,000 cases per year.
Extreme weather-related health effects	The risk of major disasters caused by severe winter gales and coastal flooding is likely to increase significantly. Death by drowning and exposure is a risk to potentially hundreds or even several thousands of people in the event of a breach, or several breaches, of a sea defence wall.
Air pollution-related health effects	In general, the effects of air pollutants on health are likely to decline but the effects of ozone during the summer are likely to increase: several thousand extra deaths and a similar number of hospital admissions may occur each year.
Water- and food-borne diseases	Water-borne diseases may increase but the overall impact is likely to be small, whereas cases of food poisoning are likely to increase significantly, by perhaps 10,000 cases per annum.
Vector-borne and rodent-borne diseases	Vector-borne diseases may present local problems but the increase in their overall impact is likely to be small.
Mental health effects	Mental health problems are likely to be significant in survivors of a major event, with some likely to be severely affected by post-traumatic stress disorder.

Source: Department of Health and Health Protection Agency, 2008

mainly due to flash floods. The evidence suggests, however, that the most important health impact among UK flood victims is on mental health, with trauma associated with personal and economic loss and stress (Parliamentary Office of Science and Technology, 2004). Data indicates a four-fold increase in psychological distress among UK adults whose homes were flooded compared with those whose were not (Reacher, *et al.*, 2004). The effects of flooding on psychological health can also be long term due to feelings of isolation and depression that remain with flood victims long after the event (Tapsell, 2001).

Indirect health impacts of flooding may also ensue from damage to hospitals, clinics and GPs, resulting in reduced accessibility to critical health services and infrastructure (HPA, 2008). However, there is little evidence about the number of hospitals, care homes, schools, nurseries and clinics in flood-risk areas on the UK coast – a subject for much-needed research.

Heatwaves, while not highlighted as an issue just for coastal areas, can also pose a problem for those with existing health problems, such as heart conditions, diabetes, respiratory or renal insufficiency, Parkinson's disease or severe mental illness (CAG Consultants, 2009). McGregor, *et al.* (2007) suggest that those living in deprived areas could be more susceptible to the effects of heatwaves owing to their association with existing poor health and housing. More frequent and prolonged heatwaves will disproportionately affect the elderly, and as high numbers of elderly people tend to live in coastal areas throughout the UK (McMichael, *et al.*, 2006), this may mean heatwaves have particularly negative impacts on coastal communities.

Higher levels of UV exposure as a result of climate change could result in an extra 5,000 cases of skin cancer and 2,000 cataract cases per year by 2050 (Parliamentary Office of Science and Technology, 2004). This could pose a particular concern for coastal communities, where people can tend to spend longer periods of time outdoors and involved in activities that require greater sun exposure, such as beach recreation or seasonal employment associated with the summer tourism industry.

In addition to these impacts, there may be increased mould-induced health effects from flooding or increased rainfall, differentially affecting infants, children, elderly people, and pregnant women who are considered to be the most vulnerable to mould-induced health problems (Center for Disease C, 2006). The

damp conditions and contamination that could be left behind as a result of flooding or intense storms could be problematic for those with low immune systems (CAG Consultants, 2009). Not only can these be a particular threat to coastal communities in terms of location, but also in terms of social vulnerabilities, such as higher numbers of at-risk groups for health problems (e.g. the elderly) and inadequate levels of housing to cope with flood or extreme weather events.

Livelihood and economic costs

Many UK coastal areas already face high deprivation and related socio-economic challenges that make them particularly vulnerable to the impacts of climate change (for example, owing to the economic decline of former seaside resorts and associated impacts on unemployment and social well-being). Extreme weather, sea level rise and coastal erosion will increasingly affect critical infrastructure such as transport and housing, as well as key economic sectors including fisheries, agriculture and recreation/ tourism, potentially worsening deprivation in more disadvantaged coastal areas and further limiting coastal communities' capacity to adapt to future climate impacts.

A report for the east of England (Globe, *et al.*, 2008) stated that key road infrastructure is or will be vulnerable to flood risk as a result of coastal or estuarine change in the short and longer term. Inland flooding due to heavy rainfall can cause major interruptions to transport, particularly in areas with already poor transport infrastructure. Business and commuter travel could also potentially be disrupted by increased traffic and accidents as road surfaces melt or crack in the weather conditions, and train services suffer delays due to buckled or fractured railway tracks (Land Use Consultants, *et al.*, 2002).

Climate change may also impact the choice, availability and quality of housing as well as property value. The effects of extreme weather events could lead to high insurance costs (Dlugolecki, 2004), in particular for those living in a 'high-risk' area along the coast. In terms of flood risk, according to estimates from the Environment Agency for England and Wales, the Department of Agriculture and Rural Development for Northern Ireland, and the Scottish Environment Protection Agency (SEPA), there are approximately 3.1 million properties across the UK (2.6 million properties in England, 357,000 properties in Wales, 46,000 properties in Northern Ireland and nearly 100,000 properties in Scotland) that are at direct risk of flooding from rivers or the sea. It has been suggested that the urban context is where the most acute problem exists, with one tidal flood event having potential to cause damage to a significant number of properties (and infrastructure) in a short period of time (RIBA & ICE, 2010). In addition, homes located in areas at risk of coastal erosion and landslip may become uninhabitable. Longer term there will be issues about how housing markets respond to changes in risk affecting households in coastal and other areas due to climate change.

Climate change impacts will have important implications for the UK commercial fishing industry as a livelihood, for the local economy and in terms of providing a large proportion of jobs (Cabinet Office, 2004). Communities that depend on fishing for their livelihoods will be especially affected by more frequent and intense storms. These could impact the number of days a vessel could be at sea, affect sea ecology and thus size of catch, or even damage a fishing fleet. Some coastal locations, such as parts of Scotland, may rely more heavily on this job market than others and have fewer alternatives, and in some cases may be involved in more dangerous forms of fishing, the danger of which could be exacerbated by climate change impacts in different UK and wider waters.

Agriculture is a key industry in many districts along the UK coast. Climate changes including increased variability of temperature and precipitation could negatively affect UK agriculture (DEFRA, 2005b). Weeds, pests and diseases are likely to expand their range as temperatures rise, and farmers may struggle to adapt to changing climate conditions. A mounting issue in the agricultural sector is the increased incidence of saltwater intrusion in irrigation systems. This is due to coastal storm surges and results in soil degradation and lower crop yields. For hotspot areas such as Yorkshire and Lincolnshire and East Anglia, where there is a predicted rise in temperature and lower precipitation levels, this could put additional

pressure on freshwater availability to local farmers, creating a compounding effect which could have serious consequences for sustained agricultural production in these areas.

Increased erosion and sea level rise will affect beaches which in some places could disappear altogether, obviously affecting seaside tourism (Phillips, *et al.*, 2006). Businesses considering development in the coastline may feel that climate change will limit inward investment and land development, which would reduce job creation and as a result worsen already high levels of deprivation in many coastal communities. An over-reliance on tourism for employment in some areas could also exacerbate the economic vulnerability of these communities if coastal erosion or extremes in temperature dissuade people from visiting the beach.

Health concerns, such as those outlined in the previous section, could also force the closure of beaches and popular leisure and recreation sites, for example as a result of contamination from storm surges at combined sewer outlets. This could have damaging repercussions for the local economy by restricting the use of popular tourism locations and thus directly lowering coastal areas' income, or by tarnishing the reputation of an area and thus indirectly lowering income through a wider general reduction in visitor numbers.

Access, quality and choice of goods and services

Many UK coastal areas are already characterised by their physical isolation, sometimes exacerbated by limited access by rail services or other public transport. A lack of access to public services, such as health and emergency services, can also be a problem. Interestingly, our literature review highlighted a general lack of knowledge and information about how climate change would impact people's access to and choice of goods and services, as well as the quality of services, in UK coastal areas. However, there are indications that certain key services are likely to be particularly affected. These include health and emergency services, public transport (particularly in areas of poor transport infrastructure), water and sewerage services, and food supply (particularly fresh produce in remote, island communities). The indirect impacts of any loss of inward investment and local business may also result in lower-quality public services, given the high levels of economic deprivation already experienced by many coastal areas.

Summary

The hotspot analysis suggests that different areas of the UK coast are expected to experience different physical impacts from climate change more acutely, including tidal flooding, increased storminess and erosion and, when coupled with the varying socio-economic make-up of the coast, there will be some unique vulnerabilities and associated challenges in coastal areas.

Climate change will pose a specific set of challenges for key public infrastructure, such as health and emergency services and public transport, along the UK coast. The local health infrastructure in these areas will be put under pressure to respond to current or recurrent health problems and also to identify and respond to unexpected future stresses and hazards, particularly from flooding and heatwaves. This will have implications for local planning, budgeting and staffing which will require co-ordinated and informed local decision-making.

The economic costs of climate change, in particular from flooding and flooding management (both coastal and fluvial), will be especially significant for coastal communities in the UK that already face high levels of deprivation. Indirect or secondary effects resulting from flooding, including those on local businesses (through potential relocation and job cuts) and the housing market, merit further investigation. Consideration of the wide variety of businesses that may be impacted, such as agricultural products, aggregates and food processing, is also needed.

At present there is also little information on how the impacts of climate change may affect access to and quality and choice of goods and services in UK coastal areas specifically. Given the range of vulnerabilities experienced by many coastal communities discussed above, any reduction in provision may be particularly difficult to mitigate.

5 Case studies

To increase our understanding of how climate change will differentially impact different types of UK coastal areas, fieldwork was carried out in four areas identified in the hotspot analysis as particularly vulnerable to the direct effects of climate change: Benbecula, Scotland; Llanelli, Wales; Skegness, England; and Great Yarmouth, England. The case studies explore levels of awareness and perception of risk among key service providers and residents in coastal communities and identify potential barriers to climate change adaptation.

Benbecula, Scotland

Benbecula is a small, low-lying island in the Outer Hebrides. It is located between the islands of North Uist and South Uist and is joined to these and other smaller islands by causeways. There is an airport and ferry points connecting Benbecula with other islands and mainland Scotland.

The population is about 1,200 and has been in decline since the mid-1970s because of the closure of a military base. It was reported that the lack of jobs for younger people has also contributed to the decline and to the ageing of the island's population. The population is very dispersed because of the abundance of crofts or small land holdings that have a property on them.

Balivanich is the site of the former army base and now the administrative centre where the council, other official buildings and the airport are located. The main economic activities in Benbecula are fishing, particularly shellfish, agriculture and ecotourism (e.g. bird watching, angling). Qinetiq is one of the largest employers on the island. The island has significant value from a nature conservation point of view due to its characteristic machair ecosystem (low lying and dune-related) and bird nesting. The island also contains important archaeological remains dating as far back as the Iron Age.

Benbecula is not an economically deprived community but it could be considered disadvantaged in other ways by its relative isolation, high fuel prices (reportedly much higher than on the mainland and other islands), an ageing population and youth outmigration. Living on the island also has advantages: for instance, no crime or traffic, a high sense of community and a spectacular environment.

Main climate risks

Interviewees reported that the island was affected by a severe storm that caused widespread flooding in January 2005. Five members of the same family died as they tried to drive on one of the causeways during the storm. The storm was reported to have caused £15 million of damage to public property, including the roads and causeways and a ferry terminal. The majority of the properties on the island were damaged. The storm also affected several beaches and caused visible erosion. Such events have the potential to isolate some of the low-lying and vulnerable parts of the island.

The island is also regularly affected by severe gales so an increase in the frequency of 'extreme' weather events could also be significant. It is possible that, with climate change, storms such as the 2005 one will become more frequent. Residents also expressed concern that an increase in storminess would have a knock-on effect on the island's connectivity as it could affect planes and ferries – with an impact on both individual mobility and the ability of local distributors to import key goods such as food.

The island's drainage system was built in the 1800s and was described as not very efficient, and

cleaned 'from time to time'. The drainage on the island may be insufficient to cope with the predicted sea level rise.

Erosion is a significant problem in the western part of the island, with some local residents reporting that the coastline's retreat has been visible over a few years in certain areas. If predictions of sea level rise are accurate, this could have a significant impact as the island is very low lying. It was reported by the local council's coastal officer that erosion had also been caused because a lot of the materials to construct the island's roads and buildings were taken from the beaches. This practice took place until quite recently as the supply of beach materials was perceived as endless.

All of those interviewed, including residents and representatives of local authorities and agencies, reported that they had noticed changes in weather patterns and the environment in recent years. These included changes to the fish and shellfish species available and to the size of catches, drier summers and wetter, windier and milder winters (except for the last two or three years).

Climate change is also expected to have a significant impact on the island ecosystems. Ecologists are concerned that some species that are unique to the island may become extinct overnight if, for instance, the freshwater habitats were flooded with seawater.

Who is going to be worst affected?

Among interviewees, no specific group was mentioned or highlighted as most at risk except those who own land or live off agriculture. However, a number of impacts were highlighted as concerns. In terms of the economy, it was noted that a change of climate could potentially impact shellfish, which is an important source of income for the island. If beaches were to disappear or if the habitats of the island were affected, this would also have an impact on tourism. There were also concerns about the possibility that residents might be unable to insure their properties in the future.

The deaths of the five members of the same family occurred because they decided that it would be safer to drive away than to stay in their house. This indicates another potential type of vulnerability stemming from a lack of understanding of the dangers associated with storm events and how to react to a particular extreme event.

Challenges for adaptation to climate change

Residents interviewed showed relatively high awareness of climate change, sea level rise and potential impacts on the island's population, livelihoods and transport (ferries in particular). They were particularly aware and concerned following the 2005 flood. Two flood action groups were established following that storm and the emergency planning group started meeting more frequently.

However, there is some understandable confusion between climate and weather. Residents cited that the last few winters have been cold and not too stormy, and in their view this raised questions about the accuracy of climate change predictions (warmer and wetter winters). Linked to the above point, the council representatives questioned whether residents were able to understand technical data related to coastal processes and climate change. Several representatives from the local authority, Scottish Natural Heritage, and the Scottish Government Rural Payments and Inspections Directorate (SGRPID) cited uncertainty in relation to climate change and sea level rise predictions. The fact that these predictions are regularly amended creates further barriers to communication with residents about the risks and actions needed.

In addition, and although residents had been traumatised by the 2005 storm and the loss of life, there was also a feeling that this had been a 'once-in-a-lifetime event' (it was described by experts as a 1-in-100-years event) and as such it would not be repeated in the near future.

Although awareness was high, there was a perception that the island is not prepared for any future similar event. This was mentioned in particular with relation to emergency planning and response (where

interviewees were concerned about a lack of training and resources) and to residents' understanding of what they should do during an event.

The 2005 storm acted as a catalyst for a number of public meetings about climate change, studies, research projects and coastal protection schemes that have been promoted by the council. Development is also being restricted in some parts of the island and flood risk data is being used to inform planning decisions. Planning for future events is also being undertaken, including a future warning system to alert residents. However, residents were of the opinion that the council had not been well prepared in 2005 and that not enough is being done to increase adaptation. This could be related to the fact that a lot of the work is ongoing and that decisions take time to be fully researched and implemented.

Several participants (both residents and organisations) were concerned about the current economic situation and the potential impacts on climate change adaptation work. In addition, residents were concerned that new infrastructure, particularly ferries and causeways, were not being designed for climate change. The roads and causeways damaged by the 2005 storm were restored to a higher standard of protection but this was seen as insufficient by residents.

Key learning points

The case-study location, Benbecula, is an example of a coastal community that is not deprived but can be considered disadvantaged in other ways because of, for instance, its relative isolation and its vulnerability to sea level rise and storminess. Benbecula is also an example of an island community. There are 291 inhabited islands around the UK and many of those are likely to share Benbecula's characteristics in terms of isolation and physical vulnerability. It is also a fairly small community so there is a question about what level of resources can be invested to protect a small island from the impacts of climate change.

The general awareness of climate change impacts was high on the island, as evidenced through our interviews. However, it was recognised that this was mostly due to the devastating effects of the 2005 storm and the activities that had been undertaken in its aftermath (flood action groups, public meetings, etc.). This is a lesson for other coastal areas or islands that may face similar risks but have not yet been affected by a significant event.

Additional potential issues relating to the communication of climate change can be gleaned from the case study. For instance, there was a feeling that an event such as the 2005 storm would not be repeated in the residents' lifetime. One explanation for this perception could be the way such events are described as '1 in 100 years' or '1 in 200 years'. This may give the impression that these types of events will not be repeated for another 100 or 200 years.

Although awareness of extreme and other events was fairly high, residents did not feel that people on the island would know how to respond during a potential future storm. Experience and awareness of the risk was reported to have led to some improvements in preparedness in the local authority but residents were concerned that this was not enough.

Llanelli, Wales

Llanelli is the largest town in Carmarthenshire with a population of approximately 35,000 and a further 20,000 in the area surrounding the urban centre. It is situated on the northern banks of the Loughor estuary in Southwest Wales and is surrounded by a number of villages and rural communities, while the Gower Peninsula, the UK's first Area of Outstanding Natural Beauty, lies opposite the town across the estuary.

Llanelli was previously dominated by heavy industry, notably tinplate and steel. A network of docks and wharfs laced the town's coastline. However, industrial activity has long since declined and Llanelli's current employment structure is dominated by the services industry and the public sector. Derelict industrial sites along the coastline are now the focus of several high-profile regeneration schemes.

Llanelli can be considered an economically deprived town. Unemployment in Llanelli is higher than the national average and the town has been particularly hard hit by the recent recession of 2008–9, with some reports claiming that unemployment in the town increased by 66 per cent over a 12-month period during this time (Greany, 2009). The town has a larger-than-national-average proportion of elderly residents and a high number of migrants from Eastern Europe have moved to the town.

Main climate risks

Drawing on evidence provided in Section 3 of this report and UKCP09, the main climate risks for Llanelli are likely to be sea level rise, storm events and surges, coastal erosion and heatwaves. Llanelli's location on the Loughor estuary heightens its sensitivity to future climate change, particularly in relation to sea level rise, which is expected to be greater in estuarine areas. Recent storm events have led to the high-profile destruction, and subsequent realignment, of the Millennium Coastal Path and to erosion at Burry Port, and sand dunes at Pembrey have reportedly been disappearing.

Participants in the two focus groups in Llanelli were all over 35. The level of awareness of climate change impacts among residents in Llanelli varied, but there was a general consensus in the local authority that awareness across the broad public was low. However, a common view among the residents interviewed was that many parts of the town could be under water in 50 years and that much of the recent public and private investment in regeneration projects was at risk from sea level rise.

Who is going to be worst affected?

There was significant concern among residents interviewed that those who are going to be worst affected by the impacts of climate change will be the elderly and those living in deprived communities close to the coast. People were aware that elderly residents are particularly vulnerable to the effects of heatwaves. Interviewees felt that those living in deprived communities close to the coast were considered to be vulnerable for a variety of reasons: they live in areas at risk of flooding; they may be unable to insure their homes or have to pay higher premiums; they may be unable to sell their homes; and they may be less likely to be able to seek out or obtain information or government assistance. The wider economic effects were highlighted by Communities First representatives and particularly the effect that climate change was already having on the cockle-picking industry.

Challenges for adaptation to climate change

Local authority representatives we spoke to suggested that key barriers for adaptation include:

- a lack of awareness of climate change impacts among the general public and particularly the elderly;
- a lack of trust in government;
- difficulties in raising awareness among migrant populations because of language barriers and cultural differences.

Residents we spoke to suggested that barriers include:

- an ageing population and youth outmigration, which means that many residents are not concerned with the long-term future of the area;
- conflicting information in the media and confusing information from government;

- observing lots of development in at-risk areas;
- poor understanding of coastal processes among developers;
- increasing levels of deprivation in the community.

Key learning points

The case-study location, Llanelli, is an example of an economically deprived area where the greatest opportunities for driving forward a successful local economy lead directly towards conflicts with adapting to the town's vulnerability to climate change. Specifically, the high-profile regeneration activities that have been recently completed or are currently underway are principally located on disused industrial land and redundant dock facilities. However, these are the areas that are at greatest risk of the effects of sea level rise, storm surges and coastal erosion.

Levels of awareness of climate change impacts in Llanelli varied and there appear to be at least isolated pockets of highly aware community groups and students. Interviewees working with community groups did note that raising awareness among some migrant communities within Llanelli presented difficulties (in comparison with long-term residents) because of language and cultural barriers. Additionally, the focus group sessions highlighted a concern that recent migrants also had a poorer understanding of the risks associated with particular locations, for example due to flooding, in comparison with long-term residents.

All interviewees and focus groups highlighted that while the elderly were considered likely to be the most vulnerable to the effects of climate change (e.g. more frequent heatwave events), they were less likely than the general population to access relevant information and support. A variety of reasons were provided to account for this, including poor IT skills and a lack of access to the internet, as well as a lack of trust in those from outside the community who are often used to market different government-led climate change initiatives (such as cavity wall insulation).

Skegness, East England

Skegness is a seaside town in Lincolnshire on the East Coast of England on the North Sea. The town is one of the better-known seaside resorts in England, which can be partly attributed to the first Butlins opening there in 1936. However, it is situated within a largely rural area and is relatively isolated. The area surrounding Skegness also has one of the largest concentrations of caravan parks in Europe. Although caravans are considered temporary accommodation, there is evidence that some people live in them permanently.

To the south of the town is Gibraltar Point National Nature Reserve, on the northern limit of The Wash. While tourism is still an important part of the economy in Skegness, like many UK resorts the town has suffered in recent years from a fall in visitor numbers, with recent summer seasons being marred by rain. After tourism, farming of the low-lying land inland of the town plays an important part in the local economy.

Skegness has a population of approximately 18,910 and in comparison with the national average includes a much higher proportion of those over 60 years old. Skegness previously received awards for being the best place to retire in the UK, but it also experiences higher-than-average levels of unemployment, with employment rates fluctuating significantly with the seasons.

In the mid-1990s an extensive programme of enhancement to the sea defences was carried out. The SMP2, which covers coastal defence for Skegness, is due to be published in autumn 2010. The draft recommendation for Skegness is to 'hold the line', meaning all people and property are protected. This will also result in the extensive protection of productive agricultural land and help ensure that the tourism industry in this area is not adversely affected in terms of flood risk (Humber ECAG, 2009).

Main climate risks

Interviewees identified the main climate risks for Skegness as infrequent flooding (particularly from rivers), changing weather patterns (including the longer, wetter winters that have been experienced in recent years) and increasing incidences of intense downpours in summer. There was widespread awareness among interviewees that the water table in and around Skegness is high, and this, combined with flat land, can mean large areas are susceptible to flooding. In the event of flooding in Skegness, therefore, the majority of the town would be inundated, not just localised areas.

In addition, interviewees suggested that the physical damage to infrastructure (road and rail) inland from Skegness from increased incidences of prolonged, cold winters is likely to exacerbate problems related to the town's isolated geography, worsening its already relatively poor transport connections.

Who is going to be worst affected?

Interviewees suggested that the elderly and retirees are most at risk from the impacts of climate change. For example, it was highlighted that in a sudden flooding event some members of these groups would be more likely to experience adverse effects because of their reduced mobility. This is compounded because the majority of housing in Skegness is single storey, so residents (including those with mobility-related disabilities) cannot escape flooding by moving to higher floors in their houses.

Information drawn from both stakeholder interviews and the national workshop indicates that there is a large population of people living almost year-round in caravans close to the sea, and these people are at significant risk of climate change impacts related to coastal flooding.

Interviewees also suggested that over the medium term, longer and wetter winters could lead to more adverse effects on health, for example by increasing the prevalence of rheumatic symptoms.

Challenges for adaptation to climate change

Business leaders and members of the local council identified that, with much of the housing being built for people who want to retire to the seaside, and the town's economy also oriented around the coast, planning restrictions in the future could reduce opportunity for development and regeneration. However, the town is seeking to increase its economic resilience, with businesses such as Butlins extending their range of activities beyond the summer season.

There is apathy among some residents towards adaptation to the impacts of climate change (which is seen as a cost burden) because they feel that they won't be around long enough for climate change to affect them. Among all those consulted, there was an identified need to ensure the co-ordination of communication and action on matters related to climate change.

Key learning points

The case-study location, Skegness, is an example of a rural coastal community that can be considered disadvantaged because of its relative isolation and higher-than-average rates of unemployment. The high water table and low-lying topography of the town and surrounding area, in combination with the risks of sea level rises and increased storm surges, heighten the area's physical vulnerability to the effects of climate change.

The demographic profile of the area also increases vulnerability to the effects of climate change, because a higher proportion of the population (in comparison with the national average) may have difficulty escaping or avoiding flooding events. This issue is compounded by the town's predominant architectural style which consists of largely single-storey dwellings, meaning that residents cannot simply go upstairs to avoid flood waters. In addition, there is a suspected 'hidden population' living in caravans all year round,

many of which are close to the coast, but there is no reliable data to accurately describe the quantity or distribution of this population.

Many of the case-study participants demonstrated higher-than-expected levels of apathy with respect to climate change. This is because they saw adaptation to climate change as an excessively expensive exercise, and the elderly residents could see no personal gain, believing that the adaptations would benefit only future generations.

Great Yarmouth, East England

The Norfolk coastal town of Great Yarmouth is around 30 km from Norwich, situated on the mouth of the River Yare. It provides access to the Norfolk Broads from the sea and one of its main industries is tourism (it has been a resort since 1760). More recently it has become an important servicing point for the offshore natural gas rigs. In the past Great Yarmouth was an important herring fishing port. Breydon Water and Halvergate Marshes, located at the rear of the town, are European-designated Special Protection Areas (SPA) and the North Denes area of the beach is home to a dune system designated a Site of Special Scientific Interest (SSSI).

Great Yarmouth (borough) has a population of approximately 93,400. Unemployment levels in the area fluctuate with the seasons and are at their lowest during the summer months. Unemployment is at its highest in the inner urban areas during the winter months when it reaches about 15 per cent. Unemployment rates are typically higher in Great Yarmouth than in the rest of the east of England and wider UK. It is a medium-sized port and industrial centre, as well as a major seaside resort, so the ongoing development of the town's 24-hour accessible port represents an important local project. Great Yarmouth has a high proportion of elderly and retired residents.

Main climate risks

Existing evidence, including that provided in Section 3 of this report, confirms the main climate risks as related to fluvial and coastal flooding. This is an ongoing issue as evidenced by the four flooding events in 2006, the North Sea flood of 1953 and a 'near miss' in November 2007 when a tidal surge and high tides resulted in limited flooding. Longer, wetter winters that are forecast to arise as a result of climate change also pose a risk to the town in light of the orientation of the local economy. Business leaders noted during interviews that these types of events would negatively affect tourist numbers, with knock-on effects on the wider local economy. A slightly older age profile also increases the sensitivity of the town's population to increasing heatwave events.

Who is going to be worst affected?

Residents between the ages of 18 and 29 who were not in employment, education or training were asked to comment on the likely effects of climate change. They had not been directly, negatively impacted by the effects of climate change in terms of flooding or heatwaves. However, they had concerns about the elderly, young children and those with disabilities, worrying that impacts could exacerbate the challenges already faced by these groups. This group was the only one that raised the issue of potential impacts on children. Possible health impacts identified included heatstroke and exacerbated asthma as a result of increased damp in housing stock.

In terms of indirect effects of climate change, other interviewees expressed concern about the impact of the negative image that would be portrayed of Yarmouth in the wake of any flooding or prolonged wet winters, as this could diminish tourist visitor numbers, which were seen as a vital part of the local economy in an area where unemployment is a concern.

Challenges for adaptation to climate change

Challenges to adaptation identified by the residents consulted included apathy towards the issue. This is partly due to a mistrust drawn from the mixed messages they receive about climate change, to the extent that they are not convinced it is an issue at all. This apathy is also related to the low priority assigned to the issue of climate change compared with immediate concerns such as providing for themselves and their families. Furthermore, there is low understanding of the connection or distinction between mitigation of climate change through measures they are made aware of (such as energy saving and the installation of renewable energy) and climate change adaptation measures in their town.

Key learning points

The case-study location, Great Yarmouth, is an example of an urban port community that experiences relatively high levels of unemployment with particular seasonal variation. The local economy is strongly connected to the sea both through shipping activities via the redeveloping port and through tourists attracted by its coastal location and associated amenities. It is also home to a high proportion of elderly and retired individuals.

There was generally a poor level of awareness and understanding of climate change exhibited by interviewees and focus groups. Participants in the focus groups highlighted significant uncertainty about whether recent weather-related events could be attributed to climate change. They were also unaware of any ongoing adaptation activities in their local area. To date, the information they had received about climate change was in relation to mitigation activities, including information about home insulation and energy efficiency.

Summary

The case studies provide interesting contrasts in terms of community awareness of the potential effects of climate change. Higher levels of awareness among some of the participating residents, as exhibited in Benbecula and Llanelli, were to a certain degree informed by direct experiences of extreme weather events and their consequences. This contrasts with lower levels of awareness in Skegness and Great Yarmouth where the focus-group participants had not experienced any recent events such as flooding.

In all but one of the case-study sites, participants in focus groups (including the elderly) and other interviewees identified the elderly as the segment of the population most vulnerable to the effects of climate change. Additionally, the elderly were also highlighted as having low levels of awareness of climate change, although this perception among interviewees was not directly tested. Identified barriers to increasing awareness and action were that elderly people did not expect to be around to experience the effects, may be unable to access climate information online, and may feel low levels of trust in those from outside the community who may visit them representing government-led initiatives. The latter was not only an issue for the elderly but also for other participants. Those with disabilities were mentioned as being particularly vulnerable in Skegness and Great Yarmouth. Participants in Great Yarmouth were also the only group to mention children as likely to be worst affected by climate change. Participants in Benbecula did not feel that any particular demographic group would be worst affected, and predicted that the worst impacts would be felt by those who depended on agriculture for a living.

With the exception of Benbecula, there was very little awareness among residents of any work being undertaken to help communities adapt to the effects of climate change. This may suggest that there is a lack of preparedness for the effects of climate change within disadvantaged coastal communities. However, as examples of publicly-led adaptation measures can be observed in each case-study area (e.g. shoreline management planning), the low levels of awareness may indicate that communities are not adequately informed of ongoing activities. In Benbecula, resident awareness had been increased as a result

of targeted engagement exercises undertaken by the local authority, including public meetings. Other local authorities interviewed did not mention similar activities.

In disadvantaged urban coastal areas such as Llanelli and Great Yarmouth, the attempt to regenerate or develop local economies may create direct tensions with the need to adapt to climate change. This is because the greatest economic opportunities have been identified in areas at the greatest risk of sea level rise, increased storm surges and coastal flooding.

6 Implications for the adaptation of coastal communities

This section discusses the overall implications of the research findings for the adaptation of coastal communities to the impacts of climate change. Our case studies and interviews uncovered a series of potential 'challenges' or barriers to successful climate change adaptation for coastal communities. Many of these challenges relate to 'adaptive capacity' and, therefore, for adaptation of coastal communities to be successful, more emphasis may need to be placed on improving climate change information, raising awareness and stimulating action, institutional and organisational development and good governance.

These challenges were presented at the project workshop, and further feedback and additional issues were raised at this event. This section covers the key barriers to adaptation for coastal communities, namely:

- ability to adapt;
- awareness and understanding of climate change risks;
- communication of climate change risks;
- negative messages and blight;
- perceived inaction;
- institutional barriers.

These barriers and challenges are not exclusive to coastal communities but, together with the socio-economic and physical issues discussed in previous sections, may contribute to increasing their vulnerability and disadvantage in the light of climate change. Many of the issues described below are interrelated and therefore the list of barriers above is slightly arbitrary and mainly serves to structure this section.

Ability to adapt

This research suggests that coastal communities will face problems adapting to the risks of climate change for a number of reasons. Household-level responses (e.g. preparing for flooding, responding to heat) may be problematic to achieve because of low levels of awareness and understanding of the impacts (explored more fully below). Hard-to-reach and hidden communities (e.g. those living permanently in caravan parks) may also be less likely to be successfully engaged in activities to promote behavioural responses. Several national stakeholders and also participants in the case studies highlighted that residents of deprived coastal communities may be less likely to be able to actively seek out information or government assistance including grants. This was mentioned particularly in relation to elderly residents (e.g. in the Llanelli case study) and those that did not have high education levels.

Several interviewees also highlighted the infrastructure issues that might cause problems for adaptation, including the potential disruption or failure of transport networks due to heavy rainfall, flooding, severe storms and prolonged heatwaves, particularly in areas of the UK coast that already have poor

transport infrastructure. Connectivity to road and rail can be poor in some coastal parts of the region, and this can increase the vulnerability of coastal communities. Decreased connectivity from fewer ferries and planes due to extreme weather was cited as particularly relevant for island communities and rural dispersed areas throughout the UK.

There is also the question of whether local authorities covering small and dispersed coastal communities will be able to afford certain types of adaptation measures, for instance flood and coastal defences or even resources for emergency responses. This is likely to be a particular issue in the next few years as cuts are made across public services.

One could argue that the ultimate adaptation measure for residents would be to move away from the coast. However, most residents we spoke to through the case studies liked living on the coast and many people want to retire to the coast. Housing in deprived coastal areas is also relatively cheap and therefore it is unlikely that many residents of these areas would want to or be able to afford to move elsewhere. This was an issue raised in our workshop in relation to coastal areas where there is very cheap housing. As soon as people move out, new people on low incomes arrive, thus creating a cycle of deprivation that is difficult to break. In our Welsh case study, it was highlighted that the best and most attractive development sites for regeneration are located near the waterfront and are therefore in the areas most at risk of climate and coastal change. This illustrates that in coastal areas there may be short-term needs (regeneration, housing) that compete with longer-term adaptation.

It was suggested by various national stakeholders that, in the long run, some coastal communities may need to be relocated as the risks become too high. This is controversial and would obviously be highly disruptive for those communities, but it also raises questions about who is going to fund this and where communities could move to.

Coastal local authorities that contain areas of high deprivation may also be less likely to be able to afford or prioritise undertaking adaptation activities. Our case studies highlighted the day-to-day concerns of service providers and residents living in coastal areas such as regeneration needs, lack of housing and the price of fuel. Climate change is therefore competing with needs that may be perceived by authorities and coastal communities as more pressing. An additional concern frequently mentioned by case-study participants is how the current economic situation may affect ongoing or future adaptation activities.

Awareness and understanding of climate change risks

In general, the case studies showed that residents have low awareness and understanding of the climate risks. The residents of Benbecula were an exception, which could be due to the fact that they had experienced a recent event. Awareness is generally higher where there has been a recent extreme event or where climate changes are more visible. Elderly people in the east of England still remember the 1953 flood which caused high loss of life. However, even in these areas awareness is often focused on a single manifestation of climate change (e.g. flooding) so the broader implications of a changing climate may not be understood. Often awareness of climate change is also centred on mitigation issues (e.g. reducing energy consumption).

In general, the national stakeholders interviewed also felt that awareness in coastal communities was generally low. Within communities, several groups were cited by the national stakeholder interviewees as being more aware, for instance farmers, those with higher education and broader skill sets, and those in employment. One explanation given for this is that these types of people are more likely to attend meetings and consultation events. One national interviewee mentioned that the traditional 'hard-to-reach' groups would not normally turn up to these events.

Raising awareness in migrant communities and among people that have moved to an area recently was mentioned as a particular challenge in the Llanelli case study. This was due partly to language and cultural barriers but also because, in comparison with longer-term residents, their knowledge of the area and risks in particular locations was believed to be a lot lower. This is likely to be a challenge for

many coastal communities, as one of the characteristics of disadvantaged coastal areas is high levels of transience in their populations.

Our case studies also showed that, among individuals in coastal communities, there is a degree of confusion between weather and climate. Awareness is in some cases based on recent weather. Some residents and business representatives in our case-study locations questioned the accuracy of climate predictions (e.g. warmer, wetter winters) in the face of the weather experienced in the last two or three years.

Isolated examples of initiatives to raise awareness of the impacts of climate change were mentioned in the interviews with local authorities for the case studies, including the organisation of various public meetings in Benbecula. However, both the local and national stakeholders interviewed were unable to identify a single initiative that was specifically aimed at awareness-raising among disadvantaged members of communities in coastal areas. One of the workshop participants also highlighted that 'awareness' in itself is not enough. She mentioned that organisations tend to put a lot of emphasis on raising awareness but this is not necessarily leading to people *understanding* the impacts of climate change and what they should do about it. This concern was echoed by participants in our case studies. For example, in Benbecula, although awareness was high following a severe storm event, residents did not feel that they were better prepared or would know how to respond in a similar future event. An additional issue in relation to awareness was raised at the workshop. 'False alarms' or raising awareness of a potential problem that may not happen means communities may not believe authorities in the future. Achieving and maintaining trust in decision-makers was seen as an important challenge.

Communication

Effective communication about climate change impacts is an important step in order to increase the awareness and understanding of impacts and support appropriate adaptation. However, our research and in particular our case studies indicate that there are problems with the way climate change and its potential impacts are communicated to coastal communities.

A key issue emerging from our case studies is the lack of a single and trusted voice or narrative about what the climate change impacts will be. Information on climate change comes from a range of sources and messages are often contradictory and confusing. People often get their information from the media. Our case-study participants reported that messages about climate change are frequently sporadic and unco-ordinated, not locally specific and not focused wholly on adaptation but mixed with mitigation information. As a result, our participants seemed to have become sceptical about the impacts of climate change. Recent coverage of climate-related news, such as the University of East Anglia leaked emails, was also mentioned at the workshop as contributing to general public scepticism and disbelief.

The lack of robust and believable climate information and the fact that predictions change regularly were also cited as barriers by local authorities interviewed as part of the case studies. Lack of understanding of technical information and data was also highlighted as a barrier. One of the local authority interviewees felt that in general people do not understand climate change predictions. Participants in the workshop also had the view that there is not enough reliable data on potential climate change impacts, which means that local authorities do not feel confident about approaching their communities.

Another key issue is the fact that climate change is often communicated as something that will happen in 20, 30 or 50 years' time, even though there is evidence that our climate is already changing. This can cause the 'not in my lifetime' mentality in elderly residents, who form a significant proportion of the population of coastal areas. The way extreme events are 'labelled' by authorities (for instance as '1 in 100 years' or '1 in 200 years' events) also gives the impression that these types of events are a once-in-a-lifetime occurrence, if that.

The communications about climate change that some case-study participants had received were often limited to issues relating to mitigation, such as recycling or reducing energy consumption. This was particularly the case in Great Yarmouth, where there was low understanding of the distinction

between mitigation of climate change through renewable energy and adaptation measures to protect the town. Communication of climate change impacts is also frequently dominated by negative messages (see next section).

As discussed above (under 'Awareness and understanding of climate change risks'), a particular issue for coastal areas is how to communicate climate change with hard-to-reach groups and how to target the transient population.

The importance of effectively communicating about climate change risks and impacts was highlighted by workshop participants, who in their recommendations prioritised measures aimed at dealing with this issue. These measures were seen as having the potential to reduce uncertainty and help to facilitate improvements to coastal community resilience. However, the possibility of causing area-based stigma or blight is a potential downside of communicating the full risks of climate change (see next section).

Negative messages and blight

Our case studies indicate that adaptation to climate change is often seen as a negative exercise that will create considerable burdens and change people's lives for the worse. This was particularly the case for some elderly participants. They felt they would not be around long enough to experience the impacts of climate change and so it would be unfair for them to bear the costs.

The negative implications are particularly present when an area is identified as 'at risk' from climate change. Residents participating in the case studies were generally worried that if their area was seen as at risk from climate change impacts, including flooding and coastal erosion, insurance premiums would rise or insurance would be refused.

Authorities in the case-study locations also raised the issue that an increased understanding of the risk of flooding and erosion, which should be a positive thing in terms of aiding preparedness, could lead to 'blighting' of some areas. Once an area is identified as being at risk of flooding or erosion, land values can fall dramatically, resulting in residents being unable to sell their homes if they want to move. This is a particular problem for areas where the current policy may be not to provide or maintain flood and coastal defences. Blight was defined in a study of the costs of adaptation on the coast as 'the negative social and economic consequences of third-party decisions. The decisions may be made by the public or private sector and may be policy or regulatory decisions.' (Taussik, *et al.*, 2006, p. 4.) According to this definition, blight is caused not just by the risk of climate impacts but by the decisions made by organisations, for instance when they publish policies that say that an area will not be defended.

Taussik, *et al.* identify three types of blighting that can affect coastal areas:

- Economic blight refers to identifiable, usually measurable, negative financial consequences of third-party decisions. It includes effects on property interests, business and investment.

- Social blight refers to identifiable, less easily measured, negative impact on people and their sense of well-being and quality of life. This can affect both individuals and communities.

- Planning blight is a narrow term, referring to the 'draining away of development value' associated with the publication of a development plan which renders land virtually unsaleable.

If an area is identified as at high risk of flooding and erosion, and no flood or coastal defences are going to be provided, this has clear implications for regeneration of coastal areas and future investment. Two stakeholder interviewees and a participant in the workshop questioned whether housing-led regeneration is appropriate for coastal areas at high risk of flooding and erosion.

We also found indications that the lack of accurate information about which areas are going to be affected by climate change (in particular flooding and erosion) can lead to rumours and misinformation among communities and businesses. This lack of information could also cause blight.

Workshop participants made several recommendations in relation to the negativity of climate change communications. For instance, it was suggested that decision-makers could showcase success stories, highlight the positives of early adaptation or even retreating communities, and encourage people to understand and accept that the coastline is dynamic and constantly changing.

Perceived inaction

The findings of the case studies indicate that there is a degree of 'apathy' in coastal communities towards climate change, and that coastal communities are not taking many steps to prepare for its impacts. Overall, a great proportion of the residents that took part in our case studies did not express much interest in climate change or were not convinced that it is an issue at all.

There are several possible explanations for this. First of all, and as we have discussed above, the way climate change is communicated and the abundance of mixed messages from different sources could be leading to mistrust within coastal communities. Action or inaction by local authorities and other agencies (see next section) can contribute to this confusion. For instance, participants in the Llanelli case study reported that a large amount of housing is being built on the floodplain, as this is an area attractive for regeneration. And participants of the case studies noted that climate change seems to have fallen off the national agenda since the start of the economic crisis.

Ageing populations and youth outmigration could also mean that some residents may not be concerned with the long-term future of their area (e.g. in Llanelli, Skegness and Great Yarmouth). While some elderly people are worried about the impacts on future generations, there is also a general 'not in my lifetime' mentality due to the great proportion of elderly people. Younger people may not have experienced a severe event, but even in those communities that have experienced one recently, there is a feeling that something like that will not happen again in their lifetimes.

Some of the case-study participants were mostly concerned about economic security and providing for themselves and their families. Compared with these day-to-day issues, climate change receives a low priority, particularly as it is still perceived by many as a future rather than current threat.

Institutional barriers

Several participants in our case studies, both residents and agencies, had the view that climate change had been a recent priority but that it seemed to have disappeared from the national agenda because of the financial crisis. Communities perceive a lack of leadership and also a lack of co-ordination among bodies that are regarded as leaders in terms of ensuring communities can adapt to the impacts of climate change. One key issue mentioned at the project workshop was a lack of clarity about who specifically is responsible for responses to climate change. Several participants commented that a 'governance mess' was a major obstacle to effective adaptation.

While developing adaptation strategies may be something more appropriate to the local level (as each coastal community will be different), the case studies highlight the lack of a clear message in relation to what we need to adapt to (impacts), what the priorities are, and who we should be targeting (e.g. areas most at risk, certain populations). At the local level, it is also evident from our research that, rather than locally relevant adaptation strategies that target disadvantaged communities, we are seeing isolated schemes and activities such as flood defences and flood action groups. These schemes and activities can be triggered by a single severe event rather than being preventative and planning for the longer term.

Adaptation will require funding, and many participants mentioned that the current economic situation and future public spending cuts are likely to affect adaptation activities and measures, some of

which would require a considerable amount of resources. Related to this, there appears to be a lack of flexibility in terms of funding. Examples of this were raised at the workshop with reference to flood-defence funding provided by the Environment Agency. In some cases, instead of providing defences, it may make more sense to use the funding for other types of adaptation, for instance relocating a few homes. However, this funding is only available to be spent on building defences.

Authorities' decisions, such as the Llanelli example of allowing building on the floodplain (see previous section), can also act as barriers to adaptation. Communities may feel that, if those with responsibility are not concerned or doing enough about climate change, then why should they be worried. Sometimes this is not a reflection of reality but rather illustrates community perceptions of inaction by authorities because their processes are long and slow.

Summary

Our research indicates that, currently, coastal communities may lack the necessary adaptive capacity that will be essential to respond to climate change. This lack can be mainly attributed to a dearth of adequate communication, support, funding, leadership and flexibility in those organisations that are responsible for climate change.

Although it is accepted and known that climate change will have widespread impacts on coastal communities, our research indicates that addressing the problems for these areas specifically is not currently a sufficient national priority. At the local level, authorities in coastal areas have to deal with a range of issues (regeneration, deprivation, housing) with limited funding, which means that preparing for climate change at the local level may be difficult. There is also a lack of knowledge and understanding at the local level of how to communicate climate impacts and in particular what needs to be done about them, by whom and when.

Our findings suggest that there is a general lack of urgency among local authorities and national agencies in relation to climate change adaptation. The consequence of this is that, currently, not enough is being done to address the potential impacts of climate change on coastal areas. There are fundamental questions that should be debated at the national level, including what areas are most at risk and what should be done to address this risk. This could include raising socially and politically unpalatable questions such as: should we be supporting some communities or householders to relocate and if so where to and who should pay for it? We also need to consider how to deal with potential area stigma and blight and how far development should continue in areas at high risk in the longer term. A national strategy to deal with climate change impacts is needed, and enough support and flexibility should be given to local authorities to ensure that their own strategies are locally relevant and prepared in partnership with their communities. Some of these issues will need to begin to be addressed through the UK Climate Change Risk Assessment currently underway and the forthcoming National Adaptation Programme.

There is presently an onus on communities to help themselves to be more resilient, but the way climate change is communicated (e.g. as a future risk) and the lack of clarity on actions needed may be leading to apathy from local communities. It is likely that this is exacerbated by the range of day-to-day challenges that more disadvantaged residents in particular face, which means that, in their view and comparatively, climate change is simply not a major issue.

7 Conclusions

Coastal areas of the UK may be severely affected by climate change in the future, and some areas are already experiencing extreme storms or flood events and the effects of sea level rise and coastal erosion. Climate change will pose risks and challenges both for people, including their physical and mental health, and for coastal economies and local industry such as fisheries, agriculture and tourism. It may also affect people's access to, and the quality of, basic goods and services such as water, food, healthcare and emergency care. The costs of emergency action, prevention and recovery may be a significant burden for coastal communities affected, with a large proportion of the costs often falling on local authorities in areas with already limited resources.

This research highlighted that some coastal communities will also face significant challenges to successful adaptation. These communities may be disadvantaged for a number of reasons; they may already be affected by poverty, deprivation and isolation. Climate change may mean they become unable to obtain insurance for their properties and face increasing physical risks of flooding, and some communities may be too small or dispersed to be able to afford certain adaptation measures such as flood defences.

The research also revealed a lack of adaptive capacity, which is likely to increase the vulnerability of disadvantaged coastal communities to climate change. Adaptation of coastal communities should be a key policy priority and it is likely to require several agencies and local and national authorities to work together and look at regeneration, flood and coastal erosion management and emergency planning.

Given that climate change will impact individuals, social groupings and communities in different UK coastal areas quite differently, climate change adaptation requires a locally-led vision with strong national support and funding. A more nuanced understanding of the diverse make-up of coastal communities and the associated vulnerabilities to predicted, regionally specific, climate change impacts is needed in national coastal defence planning. At a local level, adaptation to climate change should be a mainstreamed local priority. It is also important that investment in sea defences is linked to the wider regeneration of the area to ensure that economic and social benefits are maximised.

Better information needs to be provided for current and future generations in coastal settlements. Home-owners as well as renters, social housing tenants, caravan communities and people who live in temporary accommodation all need to be made aware of the risks associated with climate change in high-risk areas. Awareness-raising needs to support the development of understanding of what actions can be taken to reduce risks and address impacts.

In general, decision-makers need to begin to recognise the diversity of the coast and the diverse make-up of groups that reside there at present and in the future. Decision-makers need to carefully balance a nuanced understanding of climate change risks to the UK coast with continuing to encourage and value appropriate future investment in order to limit the potential for stigma of high-risk areas and for increased deprivation. Government should look at what can be improved (in terms of current policy responses) as well as building on cross-sector approaches. There needs to be better integration, including partnership and collaboration, among the key sectors in climate change adaptation policy and practice. Laying out a clear governance structure with identifiable, actionable roles and responsibilities is critical for effectively addressing the differential nature of climate change impacts likely to affect the UK coast in the near to medium-term future.

Our project did not set out to be comprehensive and some of our initial findings may benefit from further research. However, based on this exploratory study, it is evident that successful adaptation of disadvantaged coastal communities will require central government and local authorities to take further

steps to increase adaptive capacity. It is unlikely that, without intervention from institutions, disadvantaged communities will be able to become more resilient on their own. Below is our initial framework for 'successful adaptation' of disadvantaged coastal communities. It could be argued that this framework could apply to any community. However, disadvantaged groups are less likely than others to have the resources, knowledge and ability to choose where they live.

This research considers 'successful adaptation' as a combination of the following:

- **Consistent policy priority.** Adapting to the impacts of climate change needs to be a national and local policy priority. Given the severity of the potential impacts of climate change, this statement seems a bit obvious. However, participants in our research highlighted that climate change has in recent months almost disappeared from the agenda, in favour of economic concerns. If climate change impacts are not seen as a central government priority, this will reduce the incentive for local service providers and communities to consider climate change impacts. The new localism agenda may influence the management of climate change issues, with more emphasis on the local authority and on communities to take the lead. This should be sufficiently supported in terms of resources.

- **Good communication and engagement with communities.** Our research found that the way climate change is communicated by different agencies, the government and the media (e.g. without clear messages about impacts, as part of energy communications, etc.) is causing confusion and lack of trust in the messages. Good communication of climate change should contain clear messages and have an emphasis on increasing understanding of the social impacts and the actions that can be taken to respond.

- **Adaptive local and national institutions.** The research shows that the actions (or inaction) by local authorities are often maladaptive (e.g. building on the floodplain) or perceived to be so by communities (e.g. because of long processes of decision-making). This can give communities the impression that adapting to climate change is not a priority. Adaptation needs to be embedded in all policies and activities by national and local authorities. Policies should focus on the impacts of climate change on disadvantaged communities. Local authorities also need good information about the impacts of climate change and, as a starting point, how it will affect their area and communities.

- **Long-term development and infrastructure planning.** It is essential to avoid putting more people at risk of climate change. Impacts should be incorporated into local authorities' spatial planning and the control or management of development, as what is built today will be around in 50 or 100 years.

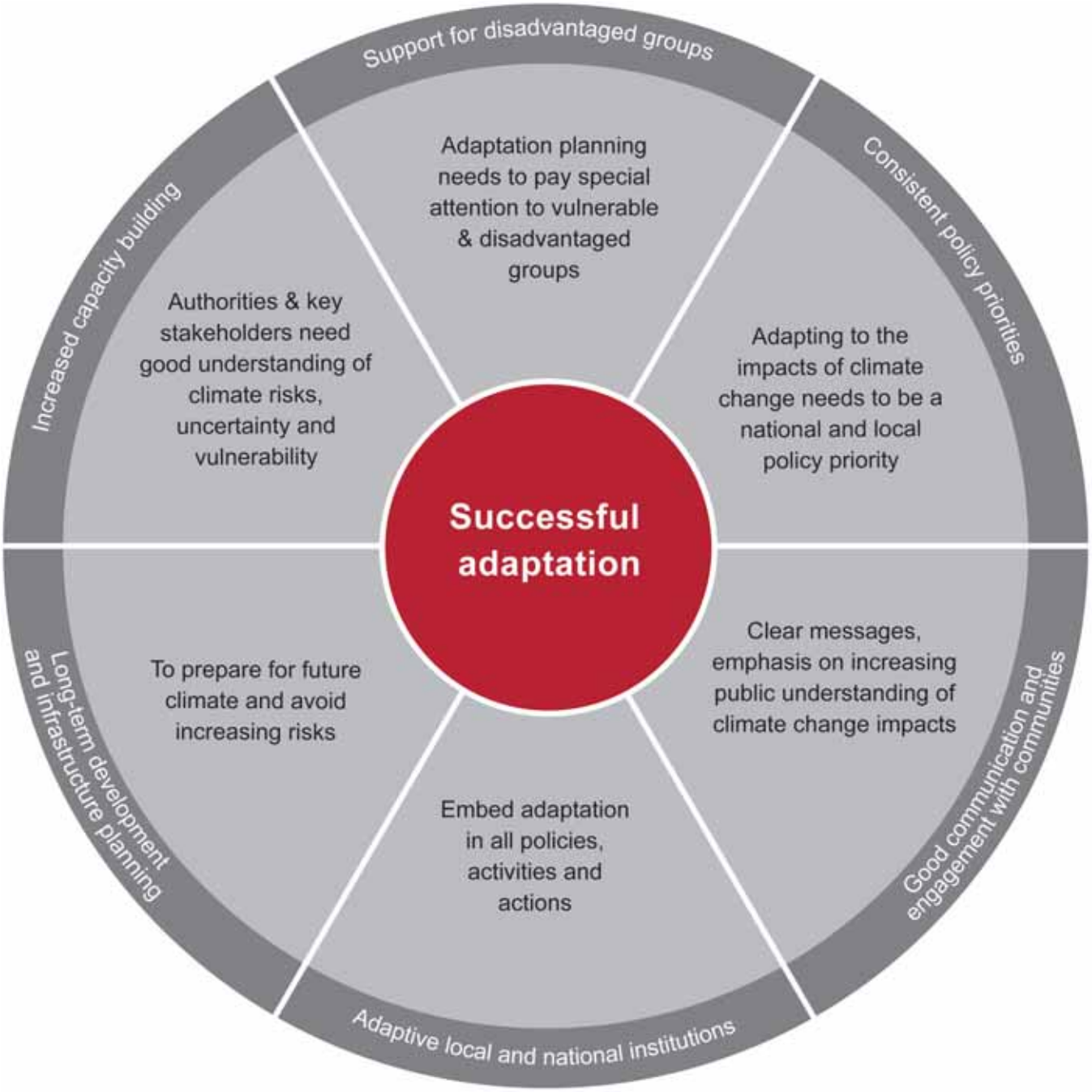
- **Increased capacity building.** In order to increase the resilience of their communities, local authorities and other key stakeholders (e.g. voluntary services) need a good understanding of the risks associated with climate change, the range of climate impacts, uncertainties related to these impacts, how to communicate information about impacts and how to embed adaptation in all their policies and activities.

- **Support for disadvantaged groups and communities.** Adaptation activities need to target disadvantaged groups and communities because it is likely that they will suffer the worst impacts.

We have created a 'successful adaptation wheel' (see Figure 7 on page 51) that summarises the key findings of this research in terms of some of the core components of successful adaptation in disadvantaged coastal communities.

In summary, our research illustrates that the coast is likely to suffer substantial impacts from climate change. In addition, some of the communities living along the coast of the UK can be considered

Figure 7: Successful adaptation wheel



particularly vulnerable to the future climate because of their socio-economic characteristics and current limitations in their ability to adapt. Our research recommends that climate change adaptation policy and practice should specifically aim to reduce the vulnerability of disadvantaged coastal communities to climate change. This should be a policy priority and the vulnerability of these communities should be considered in the ongoing climate change risk assessment. This research also points to the fact that the likely devolution of responsibility that will be a consequence of the localism agenda should be undertaken with care in relation to climate change adaptation. It is likely that many vulnerable communities and their local authorities, on the coast and possibly elsewhere, may need high levels of support from central government if they are to successfully adapt to a changing climate and reduce the risks to their population.

Notes

1 Flood and coastal erosion management are devolved matters and Scotland and Northern Ireland have their own policies with regards to flood and coastal erosion. However, Scotland and Northern Ireland do not have SMPs or equivalent policies which may reflect that coastal flooding and erosion are not considered to be as big a threat as they are for England.

2 This is true in all four countries in the UK although the statutory processes and responsible authorities are different.

3 'Longshore drift' is the name given to the process by which beach material is transported along the coast by the action of waves (Geography Site).

4 Particularly vulnerable population groups living in coastal communities include: the elderly, disabled people with mobility problems, people with chronic medical conditions, very young children, women and pregnant women (because of heat and dehydration), socially isolated groups (e.g. caravan communities), geographically isolated groups (e.g. island and dispersed rural communities), and highly deprived communities who are less able to adapt to risks.

References

Alexander, L. V. and Jones, P. D. (2001) 'Updated precipitation series for the UK and discussion of recent extremes', *Atmospheric Science Letters*, Vol. 1, DOI:10.1006/asle.2001.0025

Alexandersson, H., *et al.* (1995) *The WASA (Waves and Storms in the North Atlantic) Project: Changing Storm and Wave Climate in the Northeast Atlantic and Adjacent Seas.* Fourth International Workshop on Wave Hindcasting and Forecasting, Banff, Canada

Allan, R. (2006) 'Impacts of climate change on storminess in marine climate change', in Buckley, P. J., Dye, S. R. and Baxter, J. M. (eds) *Impacts of Climate Change on Storminess* in Marine Climate Change Impacts Annual Report Card 2006. Lowestoft: Online Summary Reports, MCCIP (Marine Climate Change Impacts Partnership)

Cabinet Office, Prime Minister's Strategy Unit (2004) *Net Benefits: A Sustainable and Profitable Future for UK Fishing*

CAG Consultants (2009) *The Differential Social Impacts of Climate Change in the UK*. Final report to SNIFFER

CCA (2010) *Coastal Regeneration Handbook.* Available at http://www.coastalcommunities.co.uk/ [Accessed 21 December 2010]

Center for Disease Control and Prevention (2006) 'Health concerns associated with mold in water-damaged homes after hurricanes Katrina and Rita: New Orleans Area, Louisiana, October 2005', *Morbidity and Mortality Weekly Report*, Vol. 55, No. 2, 20 January 2006, pp. 41–4

Centre for Rural Economy (2006) *Ageing and Coastal Communities*. Final report to the Coastal Action Zone. Available at http://www.coastalcommunities.co.uk/library/research_papers/Ageing_Communities_Report.pdf [Accessed 14 December 2009]

CLG (2007) *Coastal Towns*. House of Commons, HC351, Communities and Local Government Committee, Second Report of Session 2006–07. London: TSO

Clayton, K. and Shamoon, N. (1998) 'New approach to the relief of Great Britain II. A classification of rocks based on relative resistance to denudation', *Geomorphology*, Vol. 25, pp. 155–71

Croxton, P. J., Huber, K., Collinson, N. and Sparks, T. H. (2006) 'How well do the Central England temperature and the England and Wales precipitation series represent the climate of the UK?', *International Journal of Climatology*, Vol. 26, pp. 2287–92

Dawson, A. G., Elliott, L., Mayewski, P., Lockett, P., Noone, S., Hickey, K., Holt, T., Wadhams, P. and Foster, I. D. L. (2003) 'Late-Holocene North Atlantic climate 'seesaws', storminess changes and Greenland ice sheet (GISP2) palaeoclimates', *The Holocene*, Vol. 13, No. 3, pp. 381–92

Dawson, A., Elliott, L., Noone, S., Hickey, K., Holt, T., Wadhams, P. and Foster, I. D. L. (2004) 'Historical storminess and climate 'seesaws' in the North Atlantic region', *Marine Geology*, Vol. 210, pp. 247–59

DEFRA (2005a) *Making Space for Water: Taking Forward a New Government Strategy for Flood and Coastal Erosion Risk Management in England*

DEFRA (2005b) *The Impacts of Climate Change on Agriculture: A Vision for our Rural Landscape*

DoH and HPA (Department of Health and Health Protection Agency) (2008) *Health Effects of Climate Change in the UK 2008: An Update of the Department of Health report 2001/2002*

Dlugolecki, A. (2004) *A Changing Climate for Insurance: A Summary Report for Chief Executives and Policy-Makers.* The Association of British Insurers (ABI), June

Dornbusch, U., Robinson, D. A., Moses, C. A. and Williams, R. B. G. (2008) 'Temporal and spatial variations of chalk cliff retreat in East Sussex, 1873 to 2001', *Marine Geology*, Vol. 249, pp. 271–82

EC (n.d.) *Adaptation to Climate Change: An EU Approach*. Available at http://ec.europa.eu/environment/water/adaptation/pdf/adaptation.pdf [Accessed 6 July 2010]

Environment Agency (n.d.) *Proposed Prioritisation of Flood and Coastal Erosion Risk Management Projects.* Available at http://publications.environment-agency.gov.uk/pdf/GEHO1008BOTQ-e-e.pdf?lang=_e [Accessed 3 September 2010]

Food and Agriculture Organization (n.d.) *Adaptation to Climate Change.* Available at http://www.fao.org/climatechange/49371/en/ [Accessed 3 September 2010]

Fernández-Bilbao, A., Woodin, S., Richardson, J., Zsamboky, M., Bose, M., Orr, P., Twigger-Ross, C., Colbourne, L. (2009) *Understanding the Processes for Community Adaptation Planning on the Coast*. DEFRA Technical Report FD2624

Fletcher, S. and Potts, J. (2008) 'Coastal and marine governance in the UK: Editorial', *The Geographical Journal*, Vol. 174, No. 4, pp. 295–8

Geography Site. Available at http://www.geography-site.co.uk/pages/physical/coastal/longshore.html [Accessed 13 January 2011]

Globe Regeneration Limited, Delta Simons & Glyn Owen Associates (2008) *08-011 Coastal Initiative Socio-Economic Research Final Report.* Available at http://insighteast.org.uk/WebDocuments/Public/approved/user_9/Coastal%20Initiative%20Socio%20Economic%20Research.pdf [Accessed 21 December 2010]

Greany, S. (2009) 'Llanelli jobless figure up 66 per cent', *Llanelli Star*. Available at http://www.thisissouthwales.co.uk/news/Llanelli-jobless-figure-66-cent/article-1408514-detail/article.html [Accessed 10 September 2010]

Hansen, J. E. (2007) 'Scientific reticence and sea level rise', *Environmental Research Letters*, Vol. 2, pp. 1–6

HPA (2008) *Health Protection Agency: Flooding and Risks to Health*. Available at http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1158934608011?p=1158934608011 [Accessed 10 June 2010]

H. R. Wallingford (2010) *Climate Change Risk Assessment*. Flood and Coastal Sector Report for Consultation

Humber ECAG (Humber Estuary Coastal Authorities Group) (2009) *Flamborough Head to Gibraltar Point Shoreline Management Plan*. Available at http://www.hecag-smp2.co.uk [Accessed 1 October 2010]

IAIA [online] (International Association for Impact Assessment) *Social Impact Assessment*. Available at http://www.iaia.org/iaiawiki/sia.ashx [Accessed 20 December 2010]

Index of Multiple Deprivation for England 2007. Available at http://data.gov.uk/dataset/index_of_multiple_deprivation_imd_2007 [Accessed 15 January 2011]

Ionescu, C., Klein, R. J. T., Hinkel, J., Kavi Kumar, K. S. and Klein, R. (2005) *Towards a Formal Framework of Vulnerability to Climate Change*. NeWater Working Paper 2 and FAVAIA Working Paper 1. Potsdam: Potsdam Institute for Climate Impact Research

IPCC (2007) *Climate Change 2007: Impacts*, *Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (eds). Cambridge: Cambridge University Press

Knight, J. (2005) 'Formation of thrust structures in front of coastal landslides', *Journal of Geology*, Vol. 113, No. 1, pp. 107–14

Land Use Consultants, CAG Consultants and SQW Ltd. (2002) *Living with Climate Change in the East of England.* Summary Report. East of England Sustainable Development Round Table. England, September

McGregor, G. R., Pelling, M., Wolf, T. and Gosling, S. (2007) *The Social Impacts of Heat Waves*, Environment Agency, p. 47

McMichael, A. J., *et al.* (2006) 'Climate change and human health: Present and future risks', *The Lancet*, Vol. 367, pp. 859–69

Osborn, T. J. (2004) 'Simulating the winter North Atlantic Oscillation: The roles of internal variability and greenhouse gas forcing', *Climate Dynamics*, Vol. 22, pp. 605–23

Oxford Dictionaries. Available at http://www.oxforddictionaries.com/search?searchType=dictionary&isWritersAndEditors=true&searchUri=All&q=coast&contentVersion=WORLD [Accessed 10 September 2010]

Parliamentary Office of Science and Technology (2004) *UK Health Impacts of Climate Change*. Available at http://www.parliament.uk/documents/post/postpn232.pdf [Accessed 21 December 2010]

Parliamentary Office of Science and Technology (2009) *Coastal Management*. Available at http://www.parliament.uk/documents/post/postpn342.pdf [Accessed 3 September 2010]

Phillips, M. R. and Jones, A. L. (2006) 'Erosion and tourism infrastructure in the coastal zone: Problems, consequences and management', *Tourism Management*, Vol. 27, No. 3, pp. 517–24

Rahmsdorf, S. (2007) 'A semi-empirical approach to projecting future sea-level rise', *Science*, Vol. 315, pp. 368–70

Reacher, M., McKenzie, K., Lane, C., Nichols, T., Iversen, A., Hepple, P., Walter, T., Laxton, C. and Simpson, J. (2004) 'Health impacts of flooding in Lewes: A comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households', *Communicable Disease and Public Health*, Vol. 7, No. 1, pp. 1–8

RIBA & ICE (2010) *Facing Up to Rising Sea Levels: Retreat, Defend, Attack?* Available at http://www.ice.org.uk/downloads/Facing Up to Rising Sea Levels Document Final.pdf [Accessed: 21 December 2010]

Shennan, I., Milne, G. and Bradley, S. (2009) 'Late Holocene relative land- and sea-level changes: Providing information for stakeholders', *GSA Today*, Vol. 19, No. 9, pp. 52–3

Shennan, I., Lambeck, K., Flather, R., Horton, B. P., McArthur, J. J., Innes, J. B., Lloyd, J. M., Rutherford, M. M. and Wingfield, R. (2000) 'Modelling western North Sea palaeogeographies and tidal changes during the Holocene', in Shennan, I. and Andrews, J. E. (eds) *Holocene Land-ocean Interaction and Environmental Change around the North Sea.* London: Geological Society Publishing House, Geological Society Special Publication 166, pp. 299–319

Spickett, J., Brown, H., Katscherian, D. (2008) *Health Impacts of Climate Change: Adaptation Strategies for Western Australia.* Department of Health, Australian Government. Available at http://www.public.health.wa.gov.au/cproot/1510/2/Health_Impacts_of_Climate_Change.pdf [Accessed 31 December 2009]

Tapsell, S. (2001) *The Hidden Impacts of Flooding: Experiences from Two English Communities*. Proceedings of a symposium held at Davis, California, April 2000, Integrated Water Resources Management, IAHS Pub. No. 272, pp.319–24

Taussik, J., Ballinger, R., Ball, I., Carter, D. and Wilson, R. (2006) *Adapting to Changing Coastlines and Rivers*. Preliminary report to DEFRA, Making Space for Water, Strand SD2

Thompson, R. C., Crowe, T. P. and Hawkins, S. J. (2002) 'Rocky intertidal communities: Past environmental changes, present status and predictions for the next 25 years', *Environmental Conservation*, Vol. 29, pp. 168–91

UK Coast Guide (n.d.) Available at http://www.ukcoastguide.co.uk/ [Accessed 23 June 2010]

UKCIP (n.d.) *Types of Adaptation.* Available at http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=55&Itemid=9 [Accessed 10 September 2010]

UKCP09. Available at http://ukclimateprojections.defra.gov.uk [Accessed: 10 June 2010]

Walker, G., *et al.* (2006) *Addressing Environmental Inequalities: Flood Risk, Waste Management and River Water Quality in Wales*. Science report SC020061/SR4. Bristol: Environment Agency

Woodworth, P. L., Flather, R. A. and Shennan, I. (1999) 'A review of trends observed in British Isles mean sea level data measured from tide gauges', *Geophysical Journal International*, Vol. 136, pp. 651–70

Woodworth, P.L., Teferle, F.N., Bingley, R.M., Shennan, I. and Williams, S.D.P. (2009) 'Trends in UK mean sea level revisited', *Geophysical Journal International*, Vol. 176, pp.19–30

Source data

IPCC 2007. Available at http://www.ipcc.ch/ [Accessed 15 January 2011]

UKCP09. Available at http://ukclimateprojections.defra.gov.uk/ [Accessed 15 January 2011]

Further reading

Alcamo, J., Moreno, J. M., Nováky, B., Bindi, M., Corobov, R., Devoy, R. J. N., Giannakopoulos, C., Martin, E., Olesen, J. E. and Shvidenko, A. (2007) *Europe. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (eds). Cambridge: Cambridge University Press, pp. 541–80

Allan, R. J., Reason, C. J. C., Lindesay, J. A. and Ansell, T. J. (2003) '"Protracted" ENSO episodes and their impacts in the Indian Ocean region', *Deep-Sea Research II,* Vol. 50, No. 12–13, pp. 2331–47

Anthes, R. A., Corell, R. W., Holland, G., Hurrell, J.-W. MacCracken, M. and Trenberth, K. E. (2006) 'Hurricanes and global warming: Potential linkages and consequences', *Bulletin of the American Meteorological Society*, Vol. 87, pp. 623–8

Bacon, S. and Carter, D. J. T. (1991) 'Wind climate changes in the North Atlantic and North Sea', *International Journal of Climatology*, Vol. 11, pp. 545–58

Cabinet Office (2008) *The Pitt Review: Learning Lessons from the 2007 Floods*. London

Dawson, R. J., Hall, J. W., Bates, P. D. and Nicholls, R. J. (2005) 'Quantified analysis of the probability of flooding in the Thames Estuary under imaginable worst-case sea level rise scenarios', *Water Resources Development*, Vol. 21, No. 4, pp. 577–91

Dixon, M. J. and Tawn, J. A. (1995) *Estimates of Extreme Sea Conditions: Extreme Sea-levels at the UK A-class Sites; Optimal Site-by-Site Analyses and Spatial Analyses for the East Coast.* Proudman Oceanographic Laboratory Internal Document No. 72

Doornkamp, J. C., Gregory, K. J. and Burn, A. S. (1980) *Atlas of Drought in Britain*, 1975–1976. London: Institute of British Geographers

Fairbanks, R. G. (1989) 'A 17,000-year glacio-eustatic sea level record: Influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation', *Nature*, Vol. 342, pp. 637–42

Flather, R. A. and Williams, J. A. (2000) *Climate Change Effects on Storm Surges: Methodologies and Results*. *Climate Scenarios for Water-related and Coastal Impacts.* KNMI Workshop Report, pp. 66–72

Flather, R. A. and Williams, J. A. (2001) *Climate Change Effects on Storm Surges: Methodologies and Results*. Available at http://www.knmi.nl/~beersma/paper_flather.pdf

Fretwell, P. T., Smith, D. E. and Harrison, S. (2008) 'The last glacial maximum British-Irish ice sheet: A reconstruction using Digital Terrain Mapping', *Journal of Quaternary Science*, Vol. 23, pp. 241–8

Gehrels, R. (2006) 'Sea-level rise and coastal subsidence in Southwest England', *Reports and Transactions of the Devon Association for the Advancement of Science*, Vol. 138, pp. 25–42

Giorgi, F., Bi, X. and Pal, J. (2004) 'Mean, interannual variability and trends in a regional climate change experiment over Europe. II: Climate change scenarios (2071-2100)', *Climate Dynamics*, Vol. 23, pp. 839–58

Hansen, J. E. (2005) 'A slippery slope: How much global warming constitutes "dangerous anthropogenic interference"?', *Climatic Change*, Vol. 68, pp. 269–79

Hansen, J. E. (2007) 'Climate catastrophe', *New Scientist*, July 2007, pp. 30–4

Haslett, S. K. and Bryant, E. A. (2008) 'Historic tsunami in Britain since AD 1000: A review', *Natural Hazards and Earth System Sciences*, Vol. 8, pp. 587–601

Intergovernmental Panel on Climate Change (2007) 'Summary for Policymakers', in Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, K. B., Avery, T., Tignor, M. and Miller, H. L. (eds) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (Cambridge: Cambridge University Press)

Jones, P. D. and Conway, D. (1997) 'Precipitation in the British Isles: An analysis of area-average data updated to 1995', *International Journal of Climatology*, Vol. 17, pp. 427–38

Kaas, E., Li, T.-S. and Schmith, T. (1996) 'Statistical hindcast of wind climatology in the North Atlantic and northwestern European region', *Climate Research*, Vol. 7, pp. 97–110

Lambeck, K. (1995) 'Late Devensian and Holocene shorelines of the British Isles from models of glacio-isostatic rebound', *Journal of the Geological Society of London*, Vol. 152, pp. 437–48

Long, D. and Wilson, C. K. (2007) 'A catalogue of tsunamis in the UK', *British Geological Survey*, Edinburgh

Marsh, T., Cole, G. and Wilby, R. L. (2007) 'Major droughts in England and Wales, 1800–2006', *Weather*, Vol. 62, pp. 87–93

Massey, A. C., Gehrels, W. R., Charman, D. J., Milne, G. A., Peltier, W. R., Lambeck, K. and Selby, K. A. (2008) 'Relative sea-level change and postglacial isostatic adjustment along the coast of south Devon, United Kingdom', *Journal of Quaternary Science*, Vol. 23, No. 5, pp. 415–33

ONS (2009) *Ageing in the UK: Interactive Mapping Tool*. Available at http://www.statistics.gov.uk/ageingintheuk/default.htm [Accessed 10 September 2010]

Osborn, T. J., Hulme, M., Jones, P. D. and Basnett, T. A. (2000) 'Observed trends in the daily intensity of United Kingdom precipitation', *International Journal of Climatology*, Vol. 20, pp. 347–64

Peltier, W. R. and Fairbanks, R. G. (2006) 'Global glacial ice volume and Last Glacial Maximum duration from an extended Barbados sea level record', *Quaternary Science Reviews*, Vol. 25, pp. 3322–37

Penning-Rowsell, E., Tapsell, S. and Wilson, T. (2005) 'Key policy implications of the health effects of floods', in Kirch, W., Menne, B., Bertollini, R. (eds) *Extreme Weather and Climate Events: Risks to Human Health and Public Health Responses*. Berlin/Heidelberg: Springer-Verlag, pp. 207–23

Rossiter, J. R. (1954) 'The North Sea storm surge of 31st January and 1st February 1953', *Philosophical Transactions of the Royal Society A*, Vol. 246, pp. 371–400

Smith, D. E., Shi, S., Cullingford, R. A., Dawson, A. G., Dawson, S., Firth, C. R., Foster, I. D. L., Fretwell, P. T., Haggart, B. A., Holloway, L. K. and Long, D. (2004) 'The Holocene Storegga Slide tsunami in the United Kingdom', *Quaternary Science Reviews*, Vol. 23, pp. 2291–321

Steers, J. A. (1953) 'The East Coast floods', *The Geographical Journal*, Vol. 119, No. 3, pp. 280–95

Taylor, J. A., Murdock, A. P. and Pontee, N. I. (2004) 'A macroscale analysis of coastal steepening around the coast of England and Wales', *The Geographical Journal*, Vol. 170, pp. 179–88

UKCIP (n.d.) *Coastal Issues*. Available at http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=409&Itemid=451 [Accessed 7 January 2010]

Visbeck, M. H., Hurrell, J. W., Polvani, L. and Cullen, H. M. (2001) 'The North Atlantic Oscillation: Past, present, and future', *Proceedings of the National Academy of Sciences*, Vol. 98, No. 23, pp. 12876–7

Woodworth, P. L., Backman, P. R., Foden, S. J., Holgate, S. J., Horsburgh, K. J., Knight, P. J., Smith, D. E., Macleod, E. A. and Bradshaw, E. (2005) 'Evidence for the Indonesian tsunami in British tidal records', *Weather*, Vol. 60, No. 9, pp. 263–7

Woodworth, P. L., Flather, R. A., Williams, J. A., Wakelin, S. L., Jerejeva, S. (2007) 'The dependence of UK extreme sea levels and storm surges on the North Atlantic Oscillation', *Continental Shelf Research*, Vol. 27, pp. 935–46

Zhang, K., Douglas, B. C. and Leatherman, S. P. (2004) 'Global warming and coastal erosion', *Climatic Change*, Vol. 64, No. 1, pp. 41–58

Appendix

Abbreviations

Acronym	Full name
CCRA	Climate Change Risk Assessment
CCRM	Climate Change Risk Management
DCLG	Department for Communities and Local Government
DEFRA	Department for Environment, Food and Rural Affairs
HPA	Health Protection Agency
IPCC	Intergovernmental Panel on Climate Change
MSFW	Making Space for Water
SEPA	Scottish Environment Protection Agency
SMP	Shoreline Management Plan
UKCIP	UK Climate Impacts Programme

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