Chapter 6

Coastal erosion

The UK has a particularly long coastline that is subjected to erosion by the sea and the effects of the weather. Erosion can undermine flood defences or change the shoreline in ways that increase the risk of inland and coastal flooding.

This chapter evaluates possible future erosion rates over the next 100 years. The causes and mechanisms of the erosion are considered, and potential economic costs estimated.

6.1 Introduction

England and Wales have a coastline of approximately 3,700 km. Analysis of shoreline change shows that around 28% of the coast is experiencing erosion greater than 10 centimetres a year (0.1 m/yr). The largest erosion rates are along the east coast. However, a large proportion of the coastline is held in position artificially. A more realistic estimate of potential erosion is that 67% of the coastline is under threat (Halcrow 2002).

Work conducted for Defra (2001) has established that at present expenditure levels, approximately one-third of existing coastal defences could not be maintained in the future. This is without considering the impacts of the four climate-change scenarios from UKCIP02 that we use in this project. This degree of exposure to erosion implies that we can protect only certain areas of the country to a sufficient standard. Where we allowed defences to fail, the coast would rapidly retreat to a position more commensurate with the forcing conditions. Taking account of this limitation, approximately 20% of the coast is likely to see increased rates of erosion.

This shift in the shoreline of England and Wales is a response to a continuous rise in relative sea level that has been taking place since the last ice age. While attempts to hold the coast have not necessarily exacerbated the problem as a whole, in places they have accelerated erosion in areas with no defences. As a result, the present coastal system is out of balance with the forces acting on it. The predicted acceleration of rise in sea level under the four climate scenarios will increase the effectiveness of coastal processes that operate at sea level and will have an important impact on erosion rates.

6.2 Estimating future erosion rates

How the coast responds to changes in erosion processes and flood controls depends on the coastal morphology. There is interdependence between the various geomorphological features that make up the natural system. Evolution of one coastal feature influences evolution in adjacent areas.

The basis for predictions of coastal erosion lies mainly in records compiled during the 20th century, when rates of sea-level rise and human interference were lower. Hence, the observed trends may underestimate long-term average erosion rates.

Ignoring defences, we have calculated the relative differences between the four scenarios for climate change. We did this using basic assumptions on the nature of changes in sea level, surge activity, wave height, littoral drift, and movement of the shoreline. Our calculations allow us to predict average erosion rates at a national level (see Table 6.1). The forecasts suggest that there will be considerable variation in erosion rates, both between and within regions.

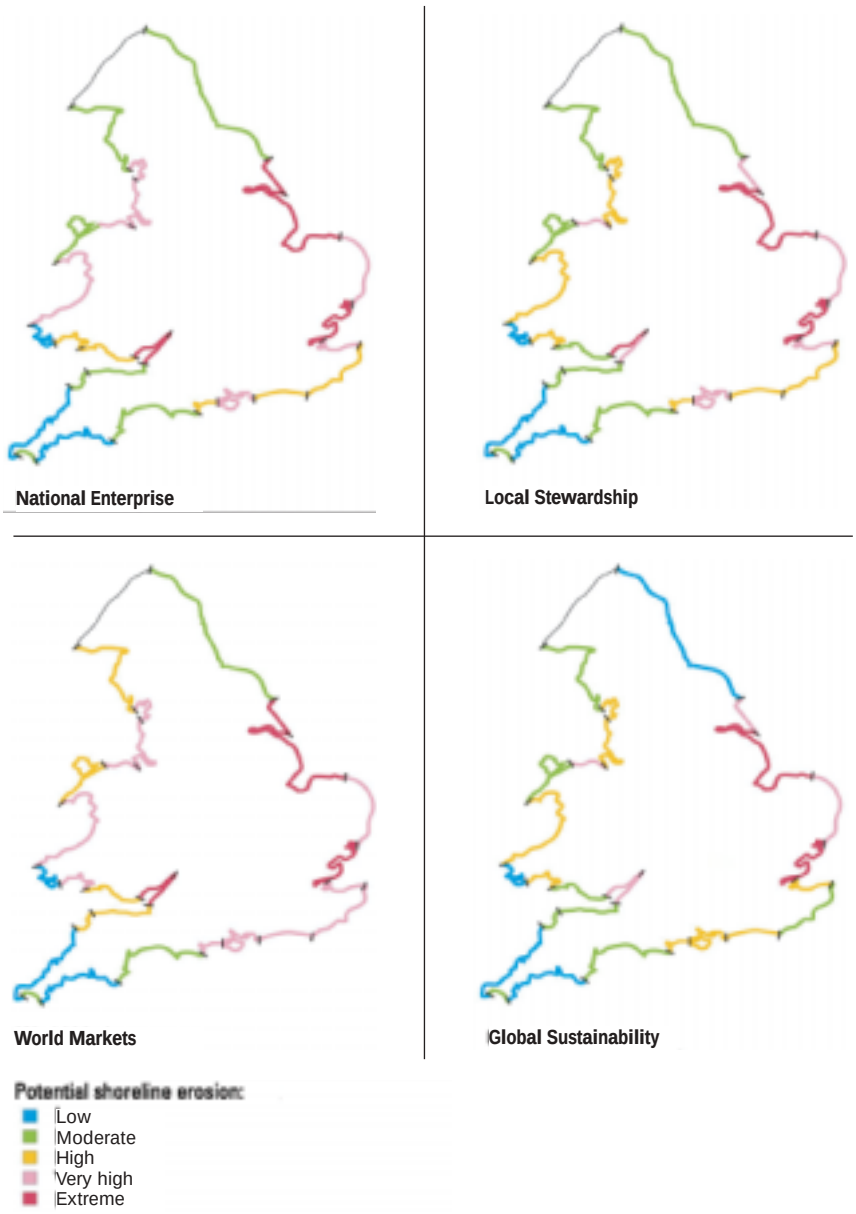
In our forecasts, many areas will experience little or no erosion of shorelines while others experience erosion of several hundred metres. However, Figure 6.1 shows that for all of the four futures scenarios (in which emissions are matched with economic growth), future erosion will be consistently severe on the east coast and major estuaries such as the Severn, Thames and Humber. As the erosion rates will (to first order) depend on the climate, results for the fifth scenario – World Markets and Low emissions – should be similar to the Global Sustainability case.

Table 6.1 **Average future erosion over 100 years for England and Wales**

Present Conditions (Benchmark)	World Markets	National Enterprise	Local Stewardship	Global Sustainability
20–67 m	141–175 m	113–150 m	99–138 m	82–123 m

Future coastal erosion in England and Wales varies according to the socioeconomic scenario we assume. This table illustrates the various forecasts of average erosion at a national level.

Figure 6.1 **Regional differences in potential shoreline erosion under the four Foresight Futures**



One possible conclusion from our analysis is that, compared to the land and assets presently within the coastal strip and at risk from erosion, losses could increase by a factor of between two and seven, depending on the socioeconomic scenario (see Table 6.1). This risk is highest under the World Markets scenario for Foresight Futures, and lowest under Global Sustainability. These figures do not, however, take full account of the constraints imposed on the shoreline by human intervention, which may reduce this impact.

6.3 The interaction between the coast and coastal defences

Throughout history, people have tried to control the coastline and how it behaves, often to minimise the loss of land or to gain land through reclamation. Along much of the shoreline of England and Wales, people have erected defences to maintain the shoreline, protect assets and to prevent the loss of hinterland. The placement of shore defences has therefore depended on the economic justification and the value of the hinterland as well as the natural geomorphology. There is less coastal defence in Cornwall, where cliffs resist erosion, than in Norfolk, where the cliffs succumb to erosion more readily.

Through holding the shoreline's position – with seawalls, beach stabilisation or groynes, for example – defences perturb the sediment budget. They do this both by restricting the input of sediment from cliffs, for example, and by groynes interrupting the sediment pathway. As well as affecting beaches locally – beach steepening in front of coastal defences is ubiquitous around the south and east coasts – there have also been down-drift impacts. Defences have also restricted the ability of dunes and beach ridges to move landward in response to rising sea level. In many areas, this has disturbed the natural dynamic equilibrium of the coastal system.

Many defended areas now lie seaward of a 'natural' position commensurate with the driving forces of waves, tides and water levels. We should not, therefore, assume that increased erosion would lead to more substantial beaches, although it may increase the shoreline's ability to keep pace with rising sea levels.

Under all four climate scenarios, the coastline will be increasingly out of balance with coastal forcing. The result will be deeper water at the coastline and increased wave energy inshore. As the performance of sea defences is intimately linked to the morphology of the shoreline in front of the structure, this will put greater pressure on existing defences and possibly accelerate their failure.

The condition and performance of defences will deteriorate through interactions between rising sea level, higher waves, more severe surges and change in the shape of the shoreline. Specifically, we will see the following effects:

- Higher water levels, as a result of sea-level rise, will mean that waves overtop defences more often.

- An increase in surge heights will produce higher extreme water levels, and thus greater water depths at the defence. This will increase the magnitude of overtopping during storms, and will exacerbate the problems described earlier.
- Greater water depths will also increase exposure of the defence to larger waves.
- There will be consequential changes to tidal and flood regimes in estuaries, especially where these are lined by fixed defences.
- Larger waves will mean that defence structures will reflect more wave energy, increasing scour of the beach, which in turn increases possible undermining of the defence.
- There will be coastal 'squeeze', due to the backshore position being held, resulting in loss of saltmarshes and beaches as well as steeper and narrower foreshores, increasing the exposure of defences.

With climate change, it will therefore become harder and more expensive to maintain defences at their current standard and position. However, as this phase of the project is predicated on the baseline assumption that the current regime of flood defences will continue, consideration of possible responses to higher flood risks are deferred to Phase 3 of the project (see Volume II).

6.4 Economic costs

In economic terms, the impacts of coastal erosion are small in relation to the national economy. Economic analysis of the coastal erosion data (see Table 6.1) indicates that associated losses, expressed as absolute costs, could increase to three to nine times the current values (Table 6.2). However, these losses are confined to a strip of coast only tens to hundreds of metres wide, even by the 2080s.

Table 6.2 **Estimates of Expected Annual Damage due to coastal erosion in England for the 2080s (£ million per annum). (Derived from Halcrow *et al*. 2000)**

	Today	World Markets	National Enterprise	Local Stewardship	Global Sustainability
North east	2.6	13	10	7	6
East Anglia	1.2	13	9	5	4
South	6.4	53	36	18	17
South west	3.2	38	27	16	15
North west	1.0	8	6	4	4
Total	**14.4**	**126**	**87**	**51**	**46**

Locally, erosion may have significant economic implications, but on a national scale these losses, even under the World Markets socioeconomic scenario, represent only about half of the estimated losses through sea and tidal flooding at the coast today (Halcrow *et al*. 2000).

In terms of the major infrastructure located on eroding coastlines, we now expect that most of the installations that currently exist will no longer be there in 50 to 100 years' time. North Sea oil and gas may be exhausted by then, eliminating the need for port capacity, oil and gas terminals and refineries. The major fixed infrastructure that will remain at the coast to 2080 are nuclear power stations. Several of these are located in coastal zones where erosion rates are moderate to high (Figure 6.1), for example, Sizewell and Dungeness (very high under World Markets), Hinkley Point (high under 'World Markets'), and Bradwell ('extreme' under 'World Markets'). Hence, while threats to infrastructure coastal erosion will not pose a significant problem at a national scale, there may still be local issues. Therefore, all key locations at risk of serious and sustained coastal erosion warrant more detailed investigation.

6.5 Coastal erosion: conclusions

In conclusion, although the national value of built assets directly at risk from coastal erosion is substantially lower than those at risk from coastal flooding, coastal flood risk is itself heavily influenced by the rate of coastal change.

In particular, defence of flood-risk areas is inextricably linked to adjacent coastal land and changes therein. Also, there is a considerable amount of important infrastructure within the coastal strip. Therefore, assuming no change in present levels of coastal defence spending, the coastal erosion predicted under all four scenarios will have significant impacts on a wide range of interests at regional and local scales.