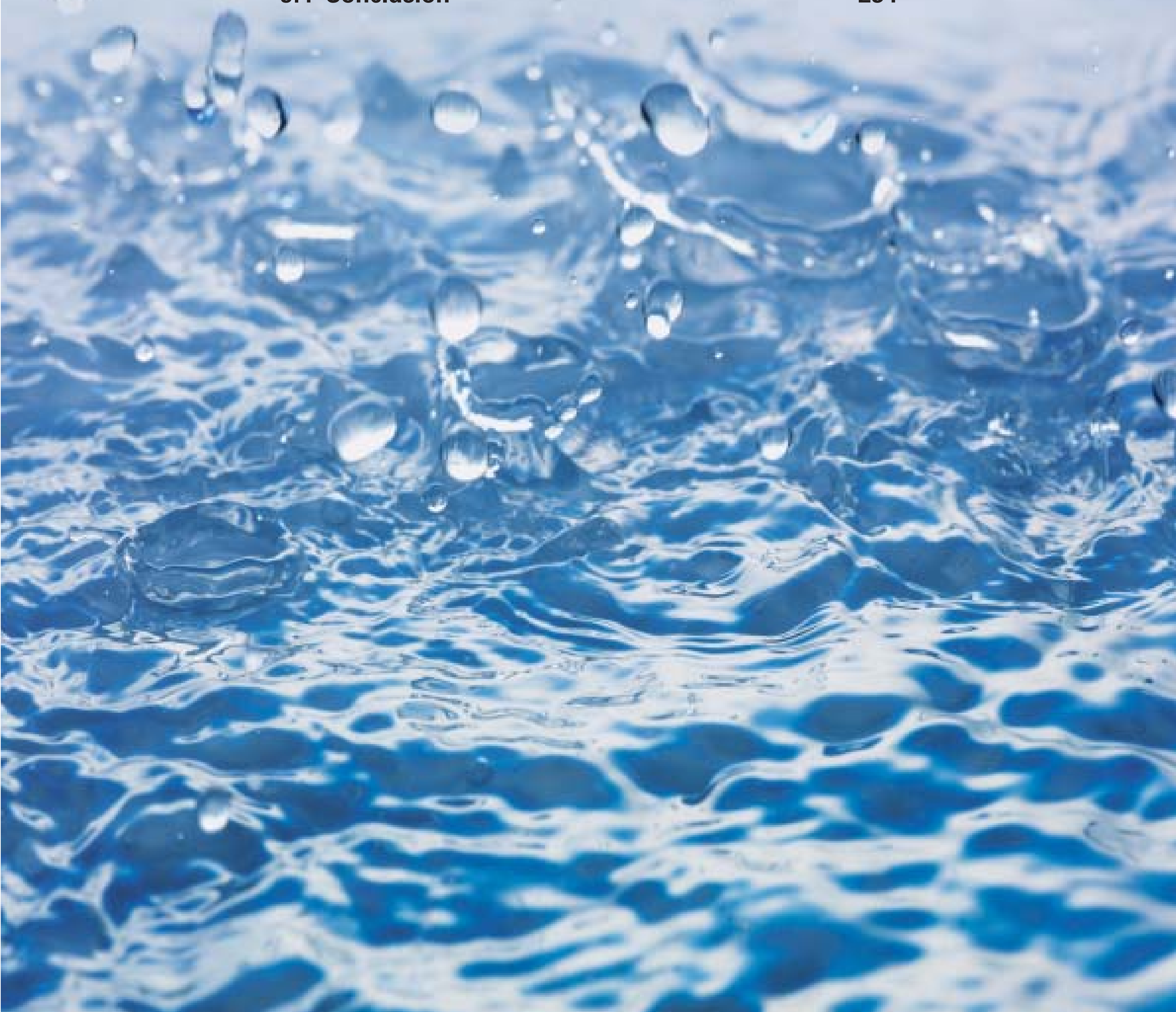

Chapter 9

Strategic choices

The Foresight Flood and Coastal Defence project has identified the potential change in flood risk by the 2080s (see Volume I). It has analysed potential responses to those risks through scenario analysis and has considered the uncertainties in both the future risks and the responses.

In this chapter, we draw these threads together to explore the implications for decision-makers. In particular, we identify and discuss some of the strategic options that are available.

9.1 Options for managing flood risk

9.1.1 Flood management

The analysis presented in Volume I indicated that if fluvial and coastal flood-defence expenditure is maintained at current levels of between £400 and £500 million/year, by the 2080s the Expected Annual Damages as a result of flooding in the fluvial and coastal zones in England and Wales could increase to somewhere between £1.5 billion under the Local Stewardship scenario and £21 billion under the World Markets scenario. Within the intra-urban area, the corresponding range is approximately £0.75 billion to £8 billion.

The reason for the increase in flood risk and, consequently, damages lies in part with climate change and in part with the pattern and extent of socioeconomic development. It should also be noted that some policy options that impact on flood risk are an integral part of the scenarios. For example, it is assumed under Global Sustainability that there will be very little new development on coastal and fluvial floodplains.

A range of responses are available to us that could reduce flood risk (Chapters 2 and 3). No single response provides an effective solution to the expected increase in flood risk (see Chapter 7). Rather, it is envisaged that the UK will need portfolios of flood response measures and that those portfolios will vary under the different future world scenarios (Chapter 4). The four portfolios we have analysed, together with the baseline flood-management assumption in Volume I, provide decision makers with a range of options applied under the four scenarios to assist in policy formulation. It should be remembered though that we have not explored all the options in detail and that other combinations of emissions and socioeconomic scenarios could occur (IPCC 2000).

The options that we have explored are shown in tables, 9.1 to 9.5. We again stress that the numbers given are indicative. In our analysis, we have been able to explore a limited range of flood-management options – they are exemplars. There is also considerable uncertainty in our numerical analysis. This uncertainty derives from the output in Chapters 5 and 6 and is a result of uncertainty in both the data and the models. This is particularly the case for the intra-urban analysis. Moreover, the costs exclude land-purchase costs and the costs of non-engineering responses.

Table 9.1 and Table 9.2 show the risks that might accrue if we continue with the present approach to flood management and current levels of expenditure. These are summed up in terms of Expected Annual Damages (EAD) relative to GDP (see Table 9.3). It should be noted that current guidance on scheme appraisal encourages: 50-100 year appraisal periods; climate change allowance; and sensitivity analysis.

Risk as a proportion of GDP rises by a third in the high growth, and high emissions of greenhouse gases, World Markets scenario, and goes down by a similar amount under Global Sustainability which is also a higher growth scenario, but with lower emissions. There is little change in the ratio under Local Stewardship, but the steep rise under National Enterprise points to the dangers of a combination of low growth and high emissions. A similar pattern applies to both catchment and coastal flood risk, and intra-urban flood risk.

Table 9.1 **Flood risks expressed as Expected Annual Damage (EAD) and the baseline costs of flood defence for the business as usual option (continuation of current flood-management policies and expenditure into the future) – catchment and coastal**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Baseline case, EAD £ million/year	1,040	20,500	15,100	1,500	4,860
Baseline cost £ million/year	500	500	500	500	500

Table 9.2 **Flood risks expressed as Expected Annual Damage (EAD) and the baseline costs of flood defence for the business as usual option (continuation of current flood-management policies and expenditure into the future) – intra-urban**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Baseline case, EAD £ million/year	270	7,880	5,060	740	1,870
Baseline cost £ million/year	320	320	320	320	320

Table 9.3 **The business as usual option – Gross Domestic Product and Expected Annual Damage**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Growth in GDP relative to present day	1.0	14.1	4.6	2.6	8.1
GDP £ billions	1,070	15,100	4,910	2,780	8,630
EAD as a percentage of GDP (%)	0.13	0.19	0.41	0.08	0.08
Total baseline cost of flood defence as a percentage of GDP (%)	0.08	0.01	0.02	0.03	0.01

Tables 9.4 and 9.5 illustrate a set of options relating to the exemplar integrated portfolios of flood-management responses. These show that the increase in flood risk in the 2080s can be pulled back to between current and twice current levels. We consider first the fluvial catchment and coastal zone (Table 9.4).

The figures for additional annual costs in Table 9.4 were calculated by dividing the total cost by 50. However, increases in expenditure are likely to increase over time to reflect affordability. It is not possible to predict the profile of these increases but, if we assume incremental growth over 80 years, the annual uplift would range between £12.5 million and £40 million. By the 2080s, this would be equivalent to a 3-7 fold increase in annual expenditure. On this basis, the increase in costs would only exceed the increase in GDP for the National Enterprise scenario.

Table 9.4 **Integrated portfolios of flood management – catchment and coastal**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Target standards of flood protection, relative to present day	1	2	2	0.75	1
Residual risks with integrated portfolio, EAD (£m/year)		1,760	1,030	930	2,040
Risk reduction, EAD (£m/year)		18,700	14,000	570	2,820
Flood-management capital costs: Englandand Wales, fluvial and coastal (£m/year)		75,600	77,200	22,100	22,400
Additional annual capital costs to achieve risk reduction (£m/year)		1,600	1,600	500	500
Total annual costs (catchment and coastal) as a percentage of GDP (%)	0.05	0.01	0.04	0.04	0.01

- Under World Markets, we supposed a doubling of the present standards of flood protection (see Chapter 4). The costs are high, but considerably below the reduction in risk, which comes down from 20 times today's level to twice that level. As noted in earlier chapters, the sustainability implications are problematic under this scenario, raising challenges for governance, particularly in relation to the implementation of engineering works and their impact on the environment and social justice.

- Under Global Sustainability, with its medium-high growth and low emissions, risk reduces to a similar level to the World Markets portfolio, but at one-third of the cost. A major element in this is that non-structural responses can be implemented better and more fully owing to more favourable governance. Present standards of flood protection are maintained under this scenario and it may well be possible to reduce risk even further in a sustainable way.
- In the world of National Enterprise the penalties of low growth and high emissions can be seen in costs which are as high as those for World Markets, but which are less affordable.

Within the intra-urban area, the portfolios of responses again reduce the expected annual damages but not to the same degree (Table 9.5). The reductions range from 34 to 61% in comparison with 38 to 93% in the fluvial catchment and coastal zone. Moreover, there is considerable residual risk, with expected annual damages ranging from 15 times (World Markets) to twice current levels. These residual levels of damage can also be expected to continue to rise with time.

Table 9.5 **Integrated portfolios of flood management – intra-urban**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Residual risks with integrated portfolio, EAD (£m/year)		4,200	2,400	490	720
Risk reduction, EAD (£m/year)		3,680	2,660	250	1,150
Flood-management costs:					
Additional costs to achieve risk reduction (£m/year)		540	260	400	110
Total annual costs (intra-urban) as a percentage of GDP	0.03	0.01	0.01	0.03	0.005

The direction of future society – that is, the scenario(s) that in fact materialise – is far from the control of flood managers, although high profile projects, such as the tidal defences of the Thames could be used as beacon projects that may help to shift societal attitudes and expectations. On the whole, however, flood managers have to work within the economic, political and institutional constraints of the day. Yet within those constraints, Government must decide on the risk of flooding it is prepared to accept. In summary, it can choose from a range of options:

- **Maintain current flood policies and expenditure, accept reduced standards of flood protection and hence a substantial increase in flood risk, and live with the increase in Expected Annual economic Damage; or**
- **Reduce flood risk by the application of a portfolio of flood response measures to levels at or similar to the present; or**
- **Reduce flood risk further, which may be difficult in economic and sustainability terms under some scenarios, but feasible under others.**

In considering these options, it should be noted that current funding already includes an element of investment for the future through the application of climate-change allowances and sensitivity analysis. This should cover some of the potential increases in probability. Furthermore, if defences are upgraded when they are being renewed in the normal asset-replacement cycle, the marginal costs of increased standards are much reduced. These have not been taken into account and would tend to balance the underestimation of the non-engineering costs.

A further issue is the need for flood-management investment, decades in advance of increased risk, and inter-generational equity. Is it justified to divert investment from other public goods in the present generation, to provide levels of protection that are likely to be more appropriate to the highter levels of wealth of future generations? The central London sewer system is an example of benefits still being derived from the farsightedness of past generations, but there is always the danger of misallocation of the national investment pot.

9.1.2 Controlling climate change

The analysis of the scenarios highlights the pressures that current systems, natural and human, will face in the future. It has shown that these are driven by changes to both climate and society.

We have not attempted a comprehensive analysis of how drivers of climate change and societal change individually contribute to the increase in flood risk. However, we have considered the potential effect of decoupling climate change from socioeconomic change.

In the first phase of the project, we quantified future flood risks for a future scenario which embodied World Markets socioeconomics (high economic growth) and low emissions of greenhouse gases (see Volume I, Chapter 4). (This is equivalent to the IPCC A1T scenario (IPCC 2000).) This showed that reducing emissions in a high-growth economy reduced annual average damages from £21 billion to £15 billion, assuming current levels of expenditure on flood management, and assuming flood-management policy remained unchanged. Thus, decoupling the drivers of climate change and socioeconomics in this one case indicates that control of global emissions can have a stabilising effect on flood risk, reducing the damages by just over 25%. Like the exemplar portfolio (Volume II, Chapter 5), it does not reduce risk to current levels, but taken together they offer an attractive combination of options.

To achieve the low climate-change scenario demands substantial decreases in emissions of greenhouse gases and changes in societal behaviour, or enormous technological investment to 'macro-engineer' the world's climate. This latter approach may be feasible and acceptable well before 2080 (Govindasamy *et al*. 2003). However, at present there is no cost comparison for these two distinct approaches. In any case, global control or mitigation of emissions does not solve the problem. Moreover, there are inherent time lags within the system, particularly in relation to sea-level rise. On the other hand, reduction of emissions will have much wider benefits beyond flood-risk reduction, nationally and globally. A reduction in greenhouse-gas emissions would signal a commitment to the type of sustainable development that is also necessary to reduce flood risk without harmful side-effects on society or the environment.

The implication of the analysis is that societal behaviour has the dominant influence on flood risk. This agrees with the RegIS report, which also concluded that coastal habitats would be affected more by the decisions that society made on how to manage the coast in the face of sea-level rise than by sea-level rise itself (Nicholls and Wilson 2002). We conclude that attempting to control the climatic driver, either by pursuing a strategy of emissions reduction or through major technological effort, would be best considered as part of the contribution to flood-risk management, alongside the evolving portfolio of responses outlined in the previous discussion. For other countries where low lying land predominates, such as Bangladesh or many island states, the imperative for mitigation rather than adaptation is obviously more urgent.

Our analysis indicates that:

- **Integrated flood-risk management must lie at the core of our response to changes in the drivers of flooding and coastal erosion, but**
- **We have the choice of whether to make the task substantially easier by pursuing mitigation policies that will reduce climate change and flooding through the control of greenhouse-gas emissions and macro-engineering the climate, and**
- **The mitigation of climate change has little potential to reduce flood risk by the middle of this century, because of time lags within the system. It will become increasingly important as we move towards the end of the current century and other responses reach their limits. But mitigation must start now if it is to deliver its benefits in time.**

9.2 A route map for flood management

A range of responses could reduce flood risk. These groups of responses are within a series of themes: Managing the Rural Landscape, Managing the Urban Fabric, Managing Flood Events, Managing Flood Losses, and River and Coastal Engineering (Chapters 2 and 3). These measures vary in their effectiveness in reducing flood risk under the different scenarios, and in their impacts on sustainability (Chapter 7). They also vary in the way that they can be implemented, in terms of governance (Chapter 8).

Having made a decision to reduce the increase in flood risk, a decision then has to be made, given the uncertainty in future flood risks, about how we implement responses. Three important dimensions emerge from this consideration: the sustainability and robustness of implementation; the timescale of implementation; and its operational control in terms of reversibility and adaptability.

9.2.1 Targeting responses: sustainability and robustness

Flood management in the UK has a history of targeting responses to flood-risk at various stages along the source-pathway-receptor continuum in an attempt to reduce both the probability of flooding and the consequential damage when floods occur. For example, one reaction to the 1953 floods in East Anglia was to reduce the risk of future coastal flooding by constructing armoured sea defences. This was subsequently supplemented by beach nourishment, to target the pathway and consequently reduce the probability of flooding. A storm-surge forecasting service was also set up to improve flood-event management and reduce losses. In recent years, we have introduced a national 'rainfall radar' system for forecasting fluvial floods. The consideration of flood risk in land-use planning has also been strengthened to manage losses. These responses are targeted at receptors.

Clearly there is a need in a portfolio approach to target responses at all stages along the source-pathway-receptor continuum, to reduce both the probability and consequences of flooding. Our analysis, however, indicates that we should favour some responses over others (see Chapter 7). These will vary depending upon the value of the assets at risk, the flood risk, cost-effectiveness, environmental impact and social justice. Responses identified as being very effective in reducing flood risk across scenarios, and which score well on sustainability criteria, include Catchment-Wide Storage, Land-Use Planning and Building Codes. These responses should be considered as a high priority. We anticipate, however, that engineering responses will remain vital in reducing flood risk under all future scenarios.

Will some responses provide more robust solutions than others in the long term? Mitigating the sources of flooding would undoubtedly provide an effective long-term solution to the problem. But as we have seen there are considerable social and technological challenges to be met if we are to reduce precipitation, surges and sea-level rise. Unless we are to depend on engineering solutions to a very great and continuing degree in managing pathways, a shift in emphasis towards targeting receptors and pathways near source would clearly help to achieve a more robust solution to the problem of future flooding through the prevention of risk. In particular:

- **Targeting pathways near source, especially in the rural and urban catchment through, for example, catchment-wide storage, reduces the probability of flooding downstream. However, the science underpinning the measures in the rural response theme is incomplete.**
- **Targeting receptors, especially through land-use planning, reduces the consequences of flooding. The Global Sustainability scenario illustrates the enormous potential of this response, in particular to reduce flood risk in the 2080s. There is the potential to build a long-term solution to the problem by targeting the people, industries and built environments – the receptors of flooding. There is, however, an obvious tension here for current policy-makers.**

In managing the urban landscape, the development of brownfield sites in flood plains at first sight appears attractive to Government and developers. However, property or new industrial development commits society to continued and increasing costs in relation to flood protection. Who pays and who benefits? If there is a major flood event, there is the question of who pays for the damages and the question of who was responsible for exposing people to risk. This raises the possibility of substantial insurance payouts, state aid and relocation costs. This would represent a market failure, with the possibility of substantial litigation, and the state being forced to intervene.

Measures that reduce the probability of flooding by targeting pathways through flood defences allow society to benefit, as it has always done, from development in floodplains. If such land is not developed, society will obviously need to look elsewhere, perhaps building at higher density outside the floodplain or developing agricultural land. Thus, it is not simply a question of how much one is prepared to pay to protect development in flood-risk areas. There are alternative questions of firstly, how much one is prepared to pay in terms of potential costs of development in other areas, and secondly of development on land that is currently protected for other equally valid reasons. The question of whether to redevelop brownfield sites in zones of active floodplain flow is particularly important for flood-risk management. Whichever decision is made, we need to develop decision-making processes that can effectively weigh up on a long timescale the full cost of flood defence and measures to reduce vulnerability.

Our analysis here indicates that we should consider the option of increased targeting of responses at the near-source and near-receptor ends of the spectrum.

The strategic questions are:

- **How we use land, balancing wider economic needs against creating a legacy of flood risk, and**
- **How we manage the balance between state and market forces.**

9.2.2 The time horizon of responses

The time horizons for the implementation of different responses vary considerably. The many options available for flood management and prevention differ in terms of their lead-in times, ease of implementation, and the duration of their effectiveness. For example, sustainable realignment schemes will require considerable lead-in times if they are to be implemented on a sufficient scale to be effective and involve significant relocation of coastal communities and infrastructure.

A portfolio of responses will inevitably need to include rapidly implemented responses to existing flood risk. Resources must also go to the measures that may take longer to demonstrate their effects, but that have cumulative or very long-term effectiveness. The attraction of such measures is that, in time, they can reduce the demand for flood-management resources. Most engineered options, on the other hand, require periodic maintenance and renovation. Moreover, the presence of engineered flood defences has in the past encouraged creeping inappropriate development that then limits subsequent flood-management options, or adds substantially to their cost. In the context of climate projections, the comparative resource requirements of the latter will increase.

A difficulty with some options is their inertia. Even if land-use planning were completely reformed to optimise floodwater control, the turnover rates are so slow for the existing stock of housing and assets that any benefits may take decades or longer to become evident. For other options, such as flood-awareness education, or the implementation of fiscal incentives, the hurdles that need to be cleared are related to the need for major social and institutional change (see Defra 2002; Treasury 1998).

The timing of the increase in flood risk is important. Under some scenarios, climate change and its impacts accelerate as the century progresses. Acting now will mean that, where there is a delay in observing the benefits (e.g. coastal realignment), or where it takes time for the responses to achieve an effect (e.g. improved building regulations and land-use planning), responses will come on stream in time to meet the increased flood risk. The alternative will be an increased reliance on structural measures that can be implemented relatively quickly as the century progresses.

Within the intra-urban zone there is considerable uncertainty as to when the structures will reach capacity and of their effective longevity. There are also considerable difficulties in retrofitting storage into existing urban areas. If we are to make full use of Storage Above and Below Ground in the urban zone we again need to address the question of inertia by reviewing and starting to implement responses within the urban zone at an early stage in areas that are at risk.

For responses that have a long lead time, the choice is:

- **To implement societal responses with a long lead in time sooner rather than later. This is a precautionary approach to the increase in flood risk, or**
- **Rely increasingly on bigger structural flood defences later, with potential cost and sustainability consequences.**

9.2.3 Adaptable, reversible and irreversible responses

Flood risk may not develop as we anticipate. What if climate change does not occur? Or what if it is much greater than we currently anticipate, or we have a collapse of the West Antarctic Ice Sheet leading to a 5-m increase in sea level rather than a 60-cm increase by 2080?

With some flood-response options, the way is left open for reversing the measures if society or climatic conditions do not change as expected. Stringent building regulations may be relaxed, some rural conveyance measures can be relaxed, we can allow building on the floodplains and remove some flood defences.
On the other hand, some decisions are effectively irreversible. In particular, releasing floodplain land for development would be very difficult to reverse once householders or industry were in place.

Adaptable design is a further aspect of operational control, especially where there is uncertainty over an increase in flood risk. Adaptive capacity can be incorporated at the design stage into physical defences, allowing incremental implementation and improvement with time – for example, constructing defences with a wider base allows top-up construction to raise standards of protection as risk is re-evaluated. Some options identified in our analysis lend themselves better to this type of approach than others, but the adaptability may come at the expense of higher initial costs. Ongoing monitoring and research that reduces uncertainty in the effectiveness of actions and which allows adaptive responses to be initiated promptly is a critical part of any portfolio of responses.

This is particularly true in dealing with major but low-probability serious events. The pressure on public funds precludes offering absolute safeguards, but there would clearly have to be some reaction. The issue is broader than merely the intensity of these 'side-swipes'. A series of severe floods in quick succession might push structural responses to their limits, while a degree of 'slack' can be built into soft options, and certainly into some community/ policy management options. Having clear knowledge of options that have reserve capacity and that can be brought forward rapidly is vital.

To manage uncertainty in future flood risk, the choice for flood managers is:

- **To favour reversible options; and**
- **To favour responses that have high adaptive capacity and allow incremental enhancements; or**
- **To face irreversible adverse consequences for flood management.**

9.3 Building a portfolio of responses

In Chapter 8 we considered some general aspects of governance that relate to portfolio management and some of the specific obstacles and opportunities in practice. In this section, we consider some of the choices that need to be addressed.

Our analysis indicates that no single response theme can effectively reduce the flood risk in even a single scenario, let alone all of the future scenarios. A portfolio of responses is required. However, the construction of the portfolio needs to be made in the light of the following considerations:

- **Ensuring effectiveness and sustainability:** All responses could play a role in such a portfolio (Chapter 2, Table 2.13). However, in seeking to define the optimum content of a preferred portfolio, it is worth remembering that the responses vary in their effectiveness across the scenarios. Moreover, only a small core (Chapter 7, Table 7.1) are deemed to be effective across all the scenarios and to carry no, or at least limited, sustainability penalties. Some indeed carry sustainability benefits.
- **Uncertainty:** The uncertainty over future climate change, flood risk and the development of society means that a range of decisions have to be made in determining the content of any portfolio of responses. Which responses should we put in place immediately? What standard of protection do we provide? Do we prioritise measures that tackle the sources and receptors of flood risk rather than adopting a head-on approach through flood defence? Over what timescale do we implement the responses? How do we maximise the flexibility of our portfolio by the use of reversible and adaptable responses that can be implemented incrementally? Furthermore, which forms of governance and incentives will be most effective in delivering these flood-risk management responses?
- **Avoiding closing off options:** It is important to consider whether decisions made in the near future may, to a greater or lesser extent, tie the hands of later generations and lock them into certain policy paths. We have already shown that the development of some brownfield sites in floodplains could lock us into increasingly expensive flood-risk reduction measures. Many of these issues are already being tackled.

- **Managing portfolios in a changing environment:** Implementing a mix of responses is not, of course, the same as designing a portfolio that can manage changing and uncertain risk. Financial investors are used to dealing with uncertainty and advocate that a portfolio of assets provides the best means of hedging future uncertainty. Given the potentially rapidly changing environment, it makes sense to focus flood-risk management on the evaluation of alternative portfolios and strategies of flood risk management (Awerbuch 2000). To inform policy making, we will also need to monitor flood risk as it changes, together with the metrics of sustainability that should also guide policy development. Some form of multi-criteria monitoring method needs to be developed to this effect.
- **Links with other policy areas:** In managing a portfolio, there must be co-ordination with other policy areas. In development planning for both rural and urban areas, flood management is a means to not just a single end, but to a nested set of aims that contribute to a better quality of life. Management of the rural environment for flood-risk reduction cannot be considered separately from the management of the rural environment for agriculture, forestry, wildlife and tourism. Experience shows the difficulty of manipulating any single sector or pursing any single aim. The recent epidemic of Foot and Mouth Disease vividly demonstrated how decisions to support the agricultural sector had a strongly negative impact on tourism. Implementation of flood management is made easier by bringing together a portfolio where the risks of the combined responses offset each other, and where the range of benefits from the responses can be aligned with a broader set of aims. This type of scrutiny may facilitate the implementation of a policy portfolio – ensuring all effects pull the same way – or show potential conflicts and pitfalls that would make implementation harder.

By analysing flood risk in terms of the three pillars of sustainability we have highlighted how flood-risk management relates to other aspects of the economy, environment and society. It remains a considerable challenge though, to develop decision-making processes across a range of sectors that will take this range of sustainability considerations into account.

We need to decide:

- **How to construct, evaluate and manage a portfolio of flood risk reduction measures; and**

- **How to take sustainability considerations into account in decision making.**

9.3.1 Science and skills

This study has highlighted the considerable uncertainty in our assessment of future flood risk and also in the effectiveness of responses. The latter is despite centuries of intervention in watercourses, flood-defence construction, urban and rural planning and design, and the more recent advances in technology and communications. We can choose to live with that uncertainty.

The alternative is to address the uncertainty and the significant gaps in knowledge that hamper effective implementation of responses. Appendices C and D highlight a range of issues that relate to further work and also the skills outlook. Here we mention just a few issues of generic importance:

- The research priorities outlined in Appendix D highlight the breadth of research that is required to advance our knowledge on the functioning and implementation of responses to future increases in flood risk. This will require the building of capacity in multi- and interdisciplinary projects that involve the engineering, natural and social sciences. Flood-management professionals will also need to broaden their skills base to address more integrated and multidisciplinary issues.

- In assessing the effectiveness of the responses in Chapters 2 and 3 we highlighted that there was considerable uncertainty in our assessments of the potential for flood-risk reduction for some of the responses. Further research is clearly needed on these responses if we are to make effective use of them (see Appendix D for details). An example is the need to establish the effectiveness of distributed storage and conveyance measures in reducing downstream flood risk, taking account of temporal variability of precipitation and spatial scale of the catchment.

- The effectiveness of response options in an uncertain world will also require that we have a greater understanding of adaptive capacity, both in terms of engineering responses and societal behaviour.

- We have identified that the capacity for integrated assessments within the intra-urban area does not match that within the fluvial catchment and coastal zones. The methodology available for the intra-urban case is at a preliminary stage and we have identified that there is a lack of appropriate tools for integrated assessment and decision-making.
- Skills (see Appendix C): we have identified that there is no evidence of a shortage in skills required for the delivery of flood risk management except in the case of civil engineers, who are predicted to be in short supply for at least the next 20 years on the basis of current trends.

Our analysis indicates that we need to:

- **Increase the breadth of research on flood-risk management and develop capacity in multi and interdisciplinary research; and**
- **Address the uncertainty in the effectiveness of key responses to reduce flood risk.**
- **Invest in social and engineering research that will increase our adaptive capacity.**
- **Develop our capacity for integrated assessment, decision making and management.**
- **Address the potential shortage of skills in the field of civil engineering.**

9.3.2 Governance options

Over and above the technical issues are matters that relate to governance and who pays. In Chapter 8 we identified a number of issues that would need to be addressed in the development of a portfolio of responses to increased flood risk. These included matching the scale of governance and response to the scale of the flood risk, integration of different elements of governance, the development of an adaptable portfolio to address the changing uncertainties, monitoring the implementation and effectiveness of response measures, and raising public awareness and risk perception. Here we highlight a number of the issues relating to governance and finance that might provide barriers to portfolio development.

Do the governance measures that we have in place now allow for effective portfolio control? How do we balance the need for strategic control with local participation and empowerment? How do we deal with the question of institutional mismatch – matching the scale of the decision-making process with the scale at which management needs to be taken? How do we deal with trade-offs associated with flood-risk management decisions? How do we decide who pays for a particular response when this varies between scenarios?

A key issue in portfolio management is *control*. To be able to exert strategic control in flood-risk management implies investment and system reconfiguration to ensure effective portfolio delivery. One stumbling-block relates to institutional mismatch with the scale of the problem that is being addressed.

The governance and implementation of responses in the Local Stewardship scenario highlight the difficulty in taking a strategic view of flood management at the larger spatial scale. With power transferred upwards to regional and international organisations such as the EU and downwards to regions and devolved localities, there are considerable challenges in developing strategic control measures that will have support at a local level where the decisions will be implemented.

Dispersed power and a complex institutional landscape confers the advantages of inclusiveness, 'buy-in', the clarity of openly negotiated and agreed responsibilities, and scope to pool and jointly prioritise resources for best results. The success of partnership approaches that bring planners, operating authorities, community representatives and the best technical and scientific knowledge together is now recognised.

However, there are also dangers in pursuing and relying on an inclusionary approach (O'Riordan 2004). These include the fact that long-term strategic policies may not be acceptable to shorter-term policy-design institutions and financing arrangements.
A precautionary and robust approach to flood management requires a degree of vision and long-term commitment. Participatory approaches also have the potential to introduce significant delays into the system. Our analysis shows that early implementation of some policies will be necessary if they are to reduce flood risk.

Finally, we come to the question of who pays. The scenarios indicate a range of possibilities from the individual to the private sector and state, and by insurance, and local and general taxation. Some major defence projects can be funded only with government involvement – even if funding is raised commercially and repaid through levies or shadow tolls – while others, such as managing flood losses, could be paid for through either self-insurance, local floodplain-charging schemes or state compensation for losses. There are choices that have to be made, especially in relation to measures that can be funded by a range of mechanisms, if we are to successfully provide a robust funding stream for individual responses.

Other costs are, of course, not direct. If we forgo building development on land as a result of flood-management policies, there are opportunity costs to be considered, for example. Clearly these need full consideration in areas where land is at a premium, and at times may require explicit trade-offs to be made, for example, releasing greenbelt land to relieve development pressure and restore natural floodplain functioning.

The nature of the institutional framework, in terms of the power balance between the public and private sectors, addresses these two elements of control and finance, but it cannot be kept separate from social trends and changing values and ethics. Exerting control in some measures, particularly some of the land-use planning measures, requires shifts in our thinking about property rights and the rights of individuals. Concerns about litigious reactions have hampered some landscape-scale actions in the past. These will continue to arise, and need careful management. In some cases, education and consensus-building may countervail, but this too could be resource-intensive.

In summary, we need to investigate:

- **Which governance structures provide the most effective means of delivering and paying for portfolios of responses in a changing and uncertain climate of future flood risk.**
- **How to match the scale of governance and response to the scale of the flood risk.**
- **How to balance effective strategic control with local participation.**

- **How to raise public awareness and risk perception.**
- **How to ensure that different elements of governance support the concept and delivery of a portfolio of responses, including monitoring the implementation and effectiveness of measures.**

9.4 Conclusion

The Foresight study described in the two volumes of this report has brought together 60 experts from a wide range of disciplines to study the risks of flooding and coastal erosion for the United Kingdom over long timescales. It has also benefited from engagement with stakeholders from across Government, business and more broadly.

While the study has considered a very broad spectrum of issues concerning flood and coastal defence, it should be regarded as a first step towards a more comprehensive analysis. Many issues remain uncertain or unresolved – the work has identified those areas where further research could most usefully be performed.

It is hoped that the project will act as a stimulus to subsequent studies that have the time and resources to dissect specific issues in more depth than was possible here. Indeed, many complementary research initiatives are already underway or starting, supported by Defra, the Environment Agency, the Research Councils and the European Commission, among others. These ongoing and future studies will serve to fill out and progressively update the insights provided here.

This report has concluded by raising a series of strategic choices for Government and other stakeholders. The choices are not easy, but this project has demonstrated how inter-disciplinary science and technology can illuminate a difficult problem and play an important role in informing the development of sustainable solutions.