Chapter 4

Integrated responses to future flood risk

Society can respond to flood risks in many ways. In Chapters 2 and 3, we analysed and ranked responses in small groups. In reality, society will draw on many different responses to manage flood risks. In this chapter, we construct a small number of integrated portfolios of responses as examples for analysis in subsequent chapters.

Four portfolios are constructed to respond to future catchment and coastal-scale flooding. These portfolios are designed to be internally consistent, and each is matched to one of the four socioeconomic scenarios. We have also constructed four further portfolios relating to intra-urban flood risk.

We define different target levels of future flood risk for each of the four scenarios – to reflect the different values, expectations and the wealth of the four future societies.

A portfolio is a set of responses, drawn from all of the possible responses to flood risk that we have identified. We have developed four portfolios, one matched to each of the Foresight Futures.

4.1 Introduction

The notion of a portfolio of responses to flood risk is not new. The Government already supports a range of measures, including the provision of flood and coastal defences, flood warning and evacuation services, as well as seeking to control inappropriate development in floodplains. The private sector also makes an important contribution to flood management, for example, through the provision of insurance and through an expanding series of products for floodproofing.

In this chapter, we describe internally consistent combinations of responses that could help to reduce flood risks. Each portfolio of responses enlists some or all of the measures examined in Chapters 2 and 3. These portfolios are not prescriptions to Government but exemplars of possible integrated approaches. They offer coherent pictures of how we might manage flood risk in the future. We assess the effectiveness of these portfolios in Chapters 5 and 6.

A theme throughout this report is that flood management within urban areas is nested within flood management at the wider level of catchments and coastal areas. In this chapter, we therefore construct separate portfolios of policies for the intra-urban environment and for the broader scale. The interactions between these two scales are, however, difficult to analyse. The processes that drive flooding at the catchment and intra-urban scales tend to be considered in isolation. In this study, we have not been able to address these interactions in a quantified manner.

To choose the responses within each portfolio, we need to consider the type of society in which flood-risk management will operate. In particular, this will influence how society implements flood-management measures – for example, whether measures are promulgated by central or local government or through the private sector. Also, society's willingness to pay, and its expectation for risk reduction, will influence future targets of protection against flood risk. Therefore, identifying scenarios of future flood management cannot take place in isolation from considerations of governance, which we will consider in greater depth in Chapter 8.

Government will continue to adapt to changing flood risk and public expectations for flood-risk management, as well as to the broader societal and environmental changes that set the context for flood management. The aim of exploring these portfolios within the future scenarios is to provide examples of potential futures that can then inform the generation of policy. The portfolios we present represent a range of possible flood-management regimes. However, more extreme futures – both in terms of the risks that must be met, and the approaches to risk management – are, of course, possible.

4.2 Portfolios for catchment-scale flood-risk management

We begin with an overview of each future scenario and draw out the responses that are most consistent with the societal values and wealth of each. These responses are identified from the groups of response to flood risk that we examined in Chapter 2 and are summarised in Table 4.1. We then provide details of the engineering measures for flood defence that are envisaged under each of the four scenarios (Table 4.2).

4.2.1 World Markets

This is the wealthiest of the Foresight Futures. By the 2080s, GDP could be 14 times its present value, in real terms. This is, therefore, a wealthy society that can afford to protect against the risks to which it is exposed. There will be a tendency to provide flood-risk management, and many other services, through markets rather than through government. This means that the ability to pay will, to a great extent, determine the level of protection against flood risks.

Under this scenario, protection of the environment will also be increasingly privatised, with protection and improvement for environmental assets and services that generate economic rents. An emphasis on economic efficiency and relative neglect of environmental considerations means that in the World Markets scenario hard-engineering measures will dominate flood management (see Chapter 2). These will be combined with the fruits of technological progress, for example, in the field of communications.

4.2.2 National Enterprise

The National Enterprise scenario is less wealthy than the World Markets scenario and more inward looking. However, it is still consumerist-oriented with economic development rated as more important than the environmental quality of rivers and coasts. It will be characterised by piecemeal and reactive engineering measures to reduce flood risk. Emphasis will be on protection of strategic industries, including agriculture.

4.2.3 Local Stewardship

This scenario is characterised by approaches to flood management that are regionally devolved and environmentally conscious. There will be a variety of approaches across the UK. Growth in national wealth, lowest in the Local Stewardship scenario, is not expected to keep pace with the rate of increase of flood risk. A consequence will be that some coastal and fluvial floodplains are abandoned, with communities working to reinstate natural systems. At the same time there is an emphasis on agricultural self-sufficiency, so some key agricultural land will be preserved regionally.

4.2.4 Global Sustainability

Government plays a leading role in providing a range of structural and non-structural measures to reduce flood risk. These measures will range from the regulation of development and the reduction of runoff to measures to help recovery after flooding, particularly for more vulnerable sectors of society.

In this scenario, Government continues to be the major institution for the delivery of society's expectations for effective risk management and environmental responsibility in the UK. Society recognises the need to balance short-term economic benefits with long-term sustainability, in order to reduce risks and share them more equitably. Flood defence engineering is employed, particularly in dense urban areas, but there is an emphasis on soft engineering, to work with, and where possible restore, natural processes. There is an emphasis on the monitoring of and adaptation to change and the implementation of measures that are resilient to future uncertainties.

Table 4.1 **Overview of flood-management scenarios in terms of four of the response themes. Engineering responses are considered in Table 4.2.**

	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Summary	Free market provision of measures to reduce impacts of flooding and hedge risks. Major engineering measures to keep pace with increasing risk.	Low regulation and limited emphasis on the environment. Piecemeal engineering measures to reduce risk, centrally-managed with limited local capabilities.	National wealth does not keep pace with increasing risk. Abandonment of fluvial and coastal floodplains. Reinstatement of natural systems. Diversity of approaches across UK regions.	Strategic regulation of development, management of runoff and reduction of impacts. Strategic soft engineering of rivers and coasts. Universal protection through public-private schemes.
Managing the Rural Landscape	Much agricultural land goes out of production. Cut-backs in subsidies means limited scope for incentives to reduce runoff.	Little change in type and level of agricultural output. Limited concerted action to reduce runoff.	Agricultural land remains under production – some intensification and shift to more environmentally-sound practices. Flood-prone areas abandoned.	Subsidies for sustainable rural practices – large-scale conversion of land-use to energy and conservation functions. Concerted measures to reduce runoff.
Managing the Urban Fabric	Unregulated land use. Urban sprawl. High-tech control of high-value urban areas.	Unregulated land use. Urban sprawl. Little adaptation of urban form and planning to accommodate changing flood risk.	Relative decline of metropolitan areas and growth of smaller cities and towns. Reconfiguration of urban areas to reduce runoff and accommodate flooding.	Efforts at reconfiguration of urban areas to reduce runoff and accommodate flooding.
Managing Flood Events	Limited efforts to co-ordinate flood event management. Private subscription flood warning services (making use of new ICT). Limited/no provision for vulnerable.	National provision of flood forecasting, flood fighting, warning and evacuation. Localised use of temporary flood defence measures.	Localised provision of flood forecasting, flood-fighting, warning and evacuation. Localised use of temporary flood-defence measures.	Concerted flood-awareness raising National (and European) provision of flood forecasting, flood fighting, warning and evacuation.
Managing Flood Losses	Increasing urbanisation in floodplains (15% to 22% by 2050). Weak building regulations mean new construction is vulnerable to flooding. Vibrant market for Floodproofing products. Ad hoc provision by wealthy. Vibrant unregulated insurance market. Non-universal availability. Weak role of local authorities in recovery, except in wealthier areas.	Increasing urbanisation in floodplains (15% to 19% by 2050). Weak building regulations mean new construction is vulnerable to flooding. Limited progress in Floodproofing of vulnerable buildings. Some private provision. Local setting of insurance premiums. Non-universal availability. Weak role of local authorities in recovery.	Limited urban development in rural areas. Emphasis on sustainability in building regulations. Community involvement in insurance provision. Strong role of local authorities in recovery.	Extent of urban area is stable, but increasing density in floodplains. National and European building regulation and dissemination of best practice. Subsidy for floodproofing. National negotiation/regulation of insurance arrangements. Risk sharing (public/private). Fairly strong role of local authorities in recovery.

Table 4.2 **Scenarios of flood-defence measures in the field of engineering**

	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Summary	Reliance on modern engineering to protect high-value land and property from flood damage. Increasingly efficient provision of hard-engineering measures.	Locally planned flood and coastal defence schemes. Piecemeal and diverse approaches. Technologically stagnant.	Soft defences to protect metropolitan areas and key infrastructures. Widespread abandonment and reinstatement of floodplains and coasts.	Strategic modern engineering with an emphasis on soft and sustainable measures. Strategic provision of hard defences in metropolitan areas. Some managed realignment.
Flood/coastal defences (embankments)	Reliance on hard defences to protect areas of high economic value.	Reliance on hard defences to protect areas of high economic value.	Retreat and abandonment. Defences to protect urban areas.	Towards soft defences. High-tech monitoring and control of soft systems.
Storage/detention (rural)	Major strategic storage systems and flood-relief channels. High-technology control.	Some storage schemes.	Major retreat from floodplains sees restoration of natural floodplain functions. Limited engineering control of these systems.	Major strategic storage systems and flood relief channels. High-tech control.
Urban drainage	Cost-cutting reduces investment in maintenance and renewal. High technology control and other technologies to maximise the performance of existing systems.	Cost-cutting reduces investment in maintenance and renewal. Increasingly challenged urban drainage system.	Emphasis on reducing urban runoff and reconfiguration of the urban environment to accommodate flooding. Limited new investment in conventional drainage infrastructure.	Increased investment in repair/renewal. High-tech control and other technologies. Urban storage (above and below ground) Design of cities for surface flows.
River management	River management to maximise conveyance, protecting environments with high-value amenity.	River management to maximise conveyance.	Widespread restoration of natural river systems.	Multi-use river management for conveyance and environment.
Coastal management	Lack of economic justification for coast protection results in collapse of some schemes and an increase in sediment supply. New hard defences in high-value areas. Measures to improve amenity, mainly privately-funded.	Piecemeal approaches to coastal management result in continued reduction in sediment supply to beaches. Measures to improve amenity.	Natural coastal processes reinstated.	Strategic coastal management, regionally and nationally coordinated. Some improvement in sediment supply to beaches. Strategic attempts to modify morphology linked to environmental and conservation goals.
Managed retreat	In areas of abandoned agricultural production.	Parochial pressures limit opportunities for managed retreat.	Widespread retreat.	Strategic managed retreat in rural and some coastal areas.
Estuary barrages	Barrage construction as flood protection and to reduce energy insecurity towards 2050s.	Barrage construction to reduce dependency on gas imports.	Thames Barrier upgrade on present alignment. No new barrages.	Thames Barrier upgrade on present alignment. No new barrages.

4.3 Standards of flood protection

An overarching feature of flood management is the extent to which society, through a combination of collective and individual actions, protects itself from flood risk. These actions include measures to: reduce the probability of flooding; reduce vulnerability and minimise the impacts of flooding.

4.3.1 Standards and influences

The Government has an interest in any commitment it makes, actual or implied, to reduce risk through the provision of flood defences and other schemes that are funded through taxation, levies, subscriptions and so on. We think of an actual or implied commitment to reduce the probability of flooding to a given limit as a standard of flood protection. This is expressed in terms of the severity of the flood that the flood-defence system is designed to resist. There are important limitations in this approach:

- It focuses on flood-defence systems and does not clearly account for the effects of many other measures of flood risk management.
- It does not account for the performance when floods are more severe than the design range of the defences.

Despite these limitations, the terminology of standard of flood protection provides a broad impression of the standard of flood risk reduction that a society, present or future, aims to achieve. It is, therefore, a useful tool and one that we use in this chapter.

The standard of flood protection will evolve through a political process that makes trade-offs between society's expectations for flood risk reduction, its cost and society's willingness to pay. Expectations for risk reduction will, in turn, depend on the perception of risk and society's attitude to different types of risk. Societies on the whole show greater tolerance for the risk of natural hazards than for man-made hazards and hazards where the risk is poorly understood. Nonetheless, in general, and in more consumerist societies in particular, we can expect reducing tolerance of flood risk in future.

The costs of achieving the standards of flood protection include direct costs, such as implementing works on the ground and providing flood warning, together with indirect costs, such as the development opportunities forgone and increased regulation of land use. The costs also have an environmental dimension – for example, costs associated with the impact of flood defences on habitats or use of natural resources.

The wealth of future societies will influence their willingness to pay for flood management. Their orientation – consumerist versus community – influences their willingness to transfer resources to particular sectors of society, such as people living on floodplains and, in particular, disadvantaged sectors of the population that may be at risk and unable to fend for themselves.

Measures to reduce risk should be *proportionate* in that the resource invested in risk reduction should roughly reflect the magnitude of the risk. In flood management terms, this is reflected in the fact that densely populated areas are afforded a greater standard of flood protection than sparsely populated rural areas. This principle is applied in most countries where there is a concerted effort to manage flood risk. However, it does depend on how society values different types of land use.

If risk to people is the focus of risk management, then population density will be the main determinant of the standard of flood protection. On the other hand, an emphasis on the protection of key industries, perhaps including agriculture, will lead to a different set of standards of flood protection related to land use. Coastal and fluvial floodplains are treated differently because flooding by the sea is more hazardous to people and causes more economic damage to houses, agriculture and industry.

4.3.2 Selecting standards

It is a challenge to estimate how a given standard of flood protection emerges from the social and political processes we have touched on. We have, however, tried to set target standards of flood protection that are consistent with the four Foresight Futures in the 2080s.

The baseline analysis described in Volume I indicates the extent to which flood risk will increase if there are no further measures to reduce risk (see Table 4.3). This analysis showed that economic damage under this baseline assumption is likely to be greatest in the World Markets and National Enterprise scenarios because of increasing probability of flooding, the growth in value of areas at risk and because of the more flood-vulnerable nature of development. However, taking the scenarios as a starting point, we also believe that there will be higher social and individual expectations for risk reduction in these consumerist-orientated scenarios. Balanced against this is the question of affordability. For instance, under the National Enterprise scenario, the resources available for flood protection could be smaller due to lower economic growth. This will feed through into lower standards of flood protection. Resources for flood management will be further stretched in the National Enterprise scenario by the need to protect strategic industries, including agriculture.

Table 4.3 **Summary of Expected Annual Damages from the baseline analysis of flood risk from Volume I**

	Present day	World Markets 2080s	National Enterprise 2080s	Local Stewardship 2080s	Global Sustainability 2080s
Total flood risks (£ billion)	1.4	28.6	20.2	2.3	6.8
GDP (£ billion)	1,070	15,100	4,910	2,780	8,630
Growth in GDP relative to present day	1.0	14.1	4.6	2.6	8.1
EAD as a percentage of GDP	0.13%	0.19%	0.41%	0.08%	0.08%

In the Global Sustainability scenario and, in particular, the Local Stewardship scenario, flood risk is likely to increase more slowly. There will be less expectation for risk reduction. On the other hand, the Global Sustainability scenario will be characterised by Government efforts to manage risks to people and the environment in a concerted and pre-emptive way. Standards of flood protection in the Local Stewardship scenario may show a great deal of national variation, reflecting local decision-making.

In the globalised scenarios – World Markets and Global Sustainability – there will be less emphasis on agriculture than in the National Enterprise and Local Stewardship scenarios. This is reflected in a withdrawal of flood protection from agricultural land other than land of a high grade. The mechanism of this withdrawal will, however, differ and is likely to occur in an unmanaged fashion in the World Markets scenario, while in the Global Sustainability scenario withdrawal will be managed and accompanied by measures to restore the environment.

Taking, as a starting point, the current standards expressed in terms of an indicative range, together with the above considerations, Table 4.4 details the standards of flood protection that have been selected for the catchment-scale flooding risks for each of the four future scenarios. A land-use band A* has been added to the customary land-use bands (A to E) to represent the most densely populated urban areas, London, for example, that currently enjoy a particularly high standard of protection. The present day standards are used to identify priority areas and many properties and highways in the floodplain have significantly less chance of being flooded.

We have also provided an indication of the percentages of defences in different condition grades (see Table 4.4). The condition grade is used in the quantified risk analysis to estimate the probability of flood-defence failure (CG1 = high standard; CG5 = poor standard). The condition grade scenarios reflect the maintenance priority that will be applied to high-impact areas.

4.4 Portfolios for intra-urban flood-risk management

The portfolios of responses which have been constructed for assessment in the intra-urban case were drawn from the six response groups identified in Chapter 3. In particular, each of these response groups has been considered against the four scenarios to assess which elements were most consistent with the values, expectations and wealth of the different societies. The mix of responses for each of the four scenarios is detailed in Table 4.5.

Table 4.4 **Standards of flood protection for the four flood-management portfolios in four scenarios (expressed in terms of return period)**

Land-use band	Comment	Present day		World Markets		National Enterprise		Local Stewardship		Global Sustainability		Condition grade (all scenarios)	
		Fluvial	Saline	Fluvial	Saline	Fluvial	Saline	Fluvial	Saline	Fluvial	Saline	Fluvial	Saline
				Above present in urban areas. No new protection for agricultural areas.		Above present in urban areas. Improved standard for agricultural areas.		General reduction in standard, apart from highest value urban areas, where standard is maintained		As present, apart from highest-value urban areas. No new protection in low-grade agri. areas.		Percentage of defences in each Condition Grade	
A✶	Where legislation takes precedence over SoP, the current legislation will be assumed under the future scenarios	e.g. 200*	e.g. 1000*	1000	10000	200	1000	100	500	1000	10000	CG1=30% CG2=50% CG3=20% CG4=0% CG5=0%	
A	Typically large urban areas at risk from flooding	50 – 200	100 – 300	200	500	200	500	50	100	100	200	CG1=10% CG2=30% CG3=45% CG4=15% CG5=0%	
B	Typically less-extensive urban areas with some high grade agricultural land	25 – 100	50 – 200	100	200	100	200	25	50	50	100	CG1=10% CG2=30% CG3=45% CG4=15% CG5=0%	
C	Typically large areas of high-grade agricultural land at risk from flooding and impeded drainage, with some properties also at risk from flooding	5 – 50	10 – 100	10	25	25	50	10	25	10	25	CG1=0% CG2=20% CG3=55% CG4=25% CG5=0%	
D	Typically mixed agricultural land with occasional, often agriculture-related, properties at risk from flooding. Agricultural land may be prone to flooding or waterlogging.	1.25 – 10	2.5 – 20	No new protection	No new protection	5	10	5	10	No new protection	No new protection	No change from present	
E	Typically low-grade agricultural land, often grass, at risk from flooding or impeded land drainage, with isolated agricultural properties at risk from flooding	1 – 2.5	1 – 5	No new protection	No new protection	2.5	5	No new protection	No new protection	No new protection	No new protection	No change from present day	

* Relates to the new category A✶ so provides an example of typical current standards rather than representing an actual standard

Table 4.5 **Individual response groups considered to be grouped together for intra-urban areas**

Response group/scenario	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Summary	Flooding confined to poorer areas. Use storage and existing/new sewerage to manage in wealthy areas.	Uncoordinated urban area form, storage and main drainage used but with less serviceability.	Parochial management emphasising buildings and local area form, above ground storage and utilisation locally. May use main drainage.	Greater tolerance of flooding. Management of buildings, urban areas, source controls, and storage above ground.
Level of Service	Above present in wealthy areas only.	Above present.	Lower than present.	Much as at present.
Building Development, Operation and Form	May be used where there are regional imperatives in terms of wealth, otherwise not effective.	Some attempts at Low Impact Development poorly coordinated and managed.	Greater tolerance of recurrent flooding. Management of risk, recovery. Community insurance. Locally Low Impact Development.	New buildings use Low Impact Development approaches. Gradual retrofit to existing buildings.
Urban Area Development, Operation and Form, (including. sacrificial areas)	Careless attitude to urban planning other than in wealthy areas. Poor areas used as sacrificial flood storage.	Confused unstructured urban land use.	Local community islands may be raised. Could be densely paved with floodwater simply passed out of the local area.	Urbanscape planned corridors for land use, although introduction in existing areas slow due to maintenance of human rights.
Source Control (+above-ground pathways)	As above, with poor areas used as flood pathways and land taken for SUDS. Only at-source control in areas where water shortages encourage harvesting.	Poor investment in buy-in by key stakeholders so only weakly taken up. Emphasis on end-of-pipe solutions.	Rainwater harvesting, Low Impact Development, recycling, and more local community activity with full source control in new areas. Gradual change in existing areas.	Rainwater harvesting, Low Impact Development, recycling, and more local community activity with full source control in new areas. Gradual change in existing areas.
Groundwater Control	Not effective.	Not effective.	May be viable locally in some areas where water supplies low. Otherwise property tanking.	Some attempts to make joint water supply/flood control work within a global perspective.
Storage Above and Below Ground	Above-ground storage in poorer areas and in planned aesthetic and recreational areas. Below-ground storage dominant otherwise with high tech operation. Willingness to invest in serviceability in key areas.	Mixed approach but with declining serviceability of underground storage systems. Developers/planners not taking up the need to use above ground systems.	Large scale centralised systems gradually abandoned. Distributed storage utilised (small locally positioned).	Most storage above ground using soft measures, e.g. water butts etc. Gradual phasing out of large centralised below ground systems. Above-ground storage may be large scale.
Main Drainage Form, Maintenance and Operation	Smarter operation and utilisation of existing infrastructure. New systems use high technology. Maintenance an essential part and of equal importance to capital investment. Decline of these systems in poorer areas.	Limited serviceability, maintenance and operational expenditure. Occasional flooding is accepted (with resignation).	Decline in main drainage. Decentralised (community) systems with local utilisation, reuse etc. Wastewater seen and used as an asset. Main drainage may be used at the community level where deemed appropriate.	Continuing use of existing assets but a gradual change over to integrated perspectives and more sustainable systems. Not necessarily SUDS. Some new systems would include pipes. Emphasis on integrated water management (floods one part of this).

4.5 Levels of service

In urban drainage, standards are at present based on Levels of Service as specified by regulators. These are target limits for the frequency of urban flooding.

Most sewerage undertakers provide more effective protection against flooding than the minimum defined by the Level of Service in Table 4.6 (although we give information for external and highway flooding, this report considers only internal property flooding in detail). Table 4.6 also includes estimates of the target standard of protection against urban flooding that might be required in each of the four scenarios in the 2080s. These are explained as follows:

World Markets: we expect the standard of protection against urban flooding to be based on the current trajectory for urban flood management, but this would apply only to part of the intra-urban area, where the wealthy reside and work. In poorer areas there may be no formal standard of protection against urban flooding, as is the case in many cities in developing countries.

National Enterprise: the standard of protection against urban flooding is based on the current trajectory of urban flood management.

Under Global Sustainability and Local Stewardship, there would be a greater tolerance of urban flooding. However, the perspectives would be slightly different:

Local Stewardship: the emphasis would be on local needs and community. In this scenario, the community would be very much involved in both active flood prevention and mitigation and in reparation to those affected. Flooding other than for property would be managed by the community and hence tolerated. However, sanitary-sewer flooding due to an inflow of stormwater may or may not be better controlled. Where foul sewage is dealt with using open systems, such as oxidation ponds, these may be at high risk of being flooded and contaminating surrounding areas. Under Local Stewardship, the passing of the flood downstream, out of the local area, may also be better tolerated.

Global Sustainability: there would be more co-ordinated management of intra-urban flooding. This would mean that the wider appreciation of the need to ensure global sustainability would promote the tolerance of occasional flooding.

Table 4.6 **Estimated standard of protection against urban flooding in terms of return period**

	Present day*	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Flooding of property	5-10	100	100	30	50
Flooding external to property	1-30	30	30	5	10
Flooding of highways	1-10	10	10	2	5

** Thresholds for 'at risk' areas used in project appraisal*