Chapter 7

Sustainability implications of flood management

In this chapter we address issues surrounding the sustainability of the different flood risk response options identified in Chapters 2 and 3 against the four different possible future scenarios – World Markets, National Enterprise, Local Stewardship and Global Sustainability.

The scenarios are not intended to predict the future, but to help clarify present-day choices by exploring the value of different options against alternative futures.

None of these scenarios is regarded from the outset as being more-or-less likely. Indeed, reality is likely to be a mixture drawn from all of these.

7.1 Sustainability implications of responses to flood risk

The assessments made in Chapters 2 and 3 of individual responses concluded that no single measure would effectively reduce flood risk on its own, and that many technically effective measures had serious negative impacts when measured against sustainability criteria, especially the one of social justice. Given the stark differences in world view that the four scenarios are intended to capture, it is unsurprising that none of the individual responses is expected to be effective in managing flood risk and meeting the sustainability criteria across all four scenarios. However, several perform well across three of the four, and might thus be considered more robust to socioeconomic and climatic change.

7.1.1 Fluvial and coastal zone

In Table 7.1 responses in the three left-hand columns shaded dark green produce a reduction in flood risk across at least three of the scenarios, *and* carry no sustainability penalties in terms of Cost-Effectiveness, Environmental Quality, or Social Justice. The lighter green responses are those that fail only on the grounds of social justice (and sometimes precaution) in one or two scenarios. The group of responses in the right hand column therefore represents those policies that are effective in reducing flood risk across most scenarios, if at times they require careful implementation because of issues over Social Justice or Precaution. Note that these policies are not necessarily the most effective in reducing flood risk (see Chapter 2).

The ideal situation is where flood-risk management options actually provide wider benefits – the win-win situation. Table 7.2 demonstrates that some options reduce flood risk under at least three scenarios *and* provide benefits in terms of Cost-Effectiveness, Environmental Quality or social justice across at least 3 scenarios (shaded in green). None of the responses produces win-win situations across the three pillars of sustainability, but it is noteworthy that Catchment-Wide Storage, Land-Use Planning and Coastal Defence Realignment potentially produce environmental benefits, reduce flood risk and either lack or have sustainability penalties that can be accommodated with careful implementation (Tables 7.1 and 7.2).

Table 7.1 **The flood response measures that produce a reduction in flood risk across at least three scenarios and which have no sustainability penalties associated with a) cost, b) the environment or c) Social Justice (dark green). Those responses which pass all three sustainability criteria (d) are labelled dark green in the right hand column. Mid-green = Social Justice failure in one scenario; light green = Social Justice failure in 2 scenarios.**

a) Cost-Effectiveness	b) Environmental Quality	c) Social Justice	d) Overall
Rural Infiltration	Rural Infiltration	Rural Infiltration	Rural Infiltration
Catchment-Wide Storage	Catchment-Wide Storage	Catchment-Wide Storage	Catchment-Wide Storage
Rural Conveyance	Rural Conveyance	Rural Conveyance	Rural Conveyance
Urban Storage	Urban Storage	Urban Storage	Urban Storage
Urban Infiltration	Urban Infiltration	Urban Infiltration	Urban Infiltration
Urban Conveyance	Urban Conveyance	Urban Conveyance	Urban Conveyance
Pre-Event Measures	Pre-Event Measures	Pre-Event Measures	Pre-Event Measures
Forecasting and Warning	Forecasting and Warning	Forecasting and Warning	Forecasting and Warning
Flood Fighting	Flood Fighting	Flood Fighting	Flood Fighting
Collective Damage Avoidance	Collective Damage Avoidance	Collective Damage Avoidance	Collective Damage Avoidance
Individual Damage Avoidance	Individual Damage Avoidance	Individual Damage Avoidance	Individual Damage Avoidance
Land-Use Management	Land-Use Management	Land-Use Management	Land-Use Management
Floodproofing	Floodproofing	Floodproofing	Floodproofing
Land-Use Planning	Land-Use Planning	Land-Use Planning	Land-Use Planning
Building Codes	Building Codes	Building Codes	Building Codes
River Conveyance	River Conveyance	River Conveyance	River Conveyance
Engineered Flood Storage	Engineered Flood Storage	Engineered Flood Storage	Engineered Flood Storage
Floodwater Transfer	Floodwater Transfer	Floodwater Transfer	Floodwater Transfer
River Defences	River Defences	River Defences	River Defences
Coastal Defences	Coastal Defences	Coastal Defences	Coastal Defences
Coastal Defence Realignment	Coastal Defence Realignment	Coastal Defence Realignment	Coastal Defence Realignment
Reduce Coastal Energy	Reduce Coastal Energy	Reduce Coastal Energy	Reduce Coastal Energy
Morphological Coastal Protection	Morphological Coastal Protection	Morphological Coastal Protection	Morphological Coastal Protection
Abandonment	Abandonment	Abandonment	Abandonment

Table 7.2 **Win-win and lose-lose responses for flood risk reduction and a) Cost-Effectiveness, b) Environmental Quality and c) Social Justice. Effective under at least three scenarios (green). Not effective under more than one scenario in reducing flood risk and incurring sustainability penalties (red)**

a) Cost-Effectiveness	b) Environmental Quality	c) Social Justice
Rural Infiltration	Rural Infiltration	Rural Infiltration
Catchment-Wide Storage	Catchment-Wide Storage	Catchment-Wide Storage
Rural Conveyance	Rural Conveyance	Rural Conveyance
Urban Storage	Urban Storage	Urban Storage
Urban Infiltration	Urban Infiltration	Urban Infiltration
Urban Conveyance	Urban Conveyance	Urban Conveyance
Pre-Event Measures	Pre-Event Measures	Pre-Event Measures
Forecasting and Warming	Forecasting and Warming	Forecasting and Warning
Flood Fighting	Flood Fighting	Flood Fighting
Collective Damage Avoidance	Collective Damage Avoidance	Collective Damage Avoidance
Individual Damage Avoidance	Individual Damage Avoidance	Individual Damage Avoidance
Land-Use Management	Land-Use Management	Land-Use Management
Floodproofing	Floodproofing	Floodproofing
Land-Use Planning	Land-Use Planning	Land-Use Planning
Building Codes	Building Codes	Building Codes
River Conveyance	River Conveyance	River Conveyance
Engineered Flood Storage	Engineered Flood Storage	Engineered Flood Storage
Floodwater Transfer	Floodwater Transfer	Floodwater Transfer
River Defences	River Defences	River Defences
Coastal Defences	Coastal Defences	Coastal Defences
Coastal Defence Realignment	Coastal Defence Realignment	Coastal Defence Realignment
Reduce Coastal Energy	Reduce Coastal Energy	Reduce Coastal Energy
Morphological Coastal Protection	Morphological Coastal Protection	Morphological Coastal Protection
Abandonment	Abandonment	Abandonment

Also highlighted in red in Table 7.2 are those options that raise concerns in their ability to reduce flood risks and meet individual sustainability criteria. Urban Storage and Floodwater Transfer give particular cause for concern followed by Urban Conveyance, Urban Infiltration, Collective Damage Avoidance and Land-Use Management.

7.1.2 Intra-urban

Only one of the responses, Urban-Area Development, Operation and Form failed significantly on the sustainability criteria as a result of the judgement made by the experts in Chapter 3 under the World Markets scenario. In two of the scenarios Urban Area Development, Operation and Form were effective and could be beneficial in sustainability terms. Those that performed reasonably well across at least three scenarios in terms of their impact on flood risk and having no negative impacts in terms of Cost-Effectiveness, Environmental Quality and Social Justice are highlighted in Table 7.3. These include Main Drainage Form, Maintenance and Operation; Storage Above and Below Ground and to a lesser extent Source Control. However, it does depend on how these are implemented.

Table 7.3 **The flood response measures in the urban zone that produce a reduction in flood risk across at least 3 scenarios and which have no sustainability penalties associated with a) Cost-Effectiveness b) Environmental Quality or c) Social Justice (dark green). Those responses which pass all three sustainability criteria (d) are labelled dark green in the right hand column. Mid-green = Social Justice failure in one scenario.**

a) Cost-Effectiveness	b) Environmental Quality	c) Social Justice	d) Overall
Building Development	Building Development, Operation and Form	Building Development, Operation and Form	Building Development, Operation and Form
Urban-Area Development Operation and Form	Urban- Area Development Operation and Form	Urban-Area Development Operation and Form	Urban-Area Development Operation and Form
Source Control	Source Control	Source Control	Source Control
Groundwater Control	Groundwater Control	Groundwater Control	Groundwater Control
Storage Above and and Below Ground	Storage Above and and Below Ground§	Storage Above and and Below Ground	Storage Above and and Below Ground
Main Drainage Form, Maintenance and Operation	Main Drainage Form, Maintenance and Operation	Main Drainage Form, Maintenance and Operation	Main Drainage Form, Maintenance and Operation

Three responses (Table 7.4) reduce flood risk in at least three scenarios and provide benefits in terms of either Cost-Effectiveness or Environmental Quality, but again none of the responses produces win-win situations across the three pillars of sustainability. The two responses that provide cause for concern in their ability to reduce flood risk under more than one scenario, while also incurring sustainability penalties, are Building Development, Operation and Form and Groundwater Control.

Table 7.4 **Win-win and lose-lose responses for flood risk reduction and a) Cost-Effectiveness, b) Environmental Quality and c) Social Justice. Effective under at least three scenarios (green). Not effective under more than one scenario in reducing flood risk and incurring sustainability penalties (red)**

a) Cost-Effectiveness	b) Environmental Quality	c) Social Justice
Building Development, Operation and Form	Building Development, Operation and Form	Building Development, Operation and Form
Urban-Area Development Operation and Form	Urban-Area Development Operation and Form	Urban-Area Development Operation and Form
Source Control	Source Control	Source Control
Groundwater Control	Groundwater Control	Groundwater Control
Storage Above and Below Ground	Storage Above and Below Ground	Storage Above and Below Ground
Main Drainage Form, Maintenance and Operation	Main Drainage Form, Maintenance and Operation	Main Drainage Form, Maintenance and Operation

7.2 Cost-Effectiveness

The appraisal of flood risk responses in Chapter 2 indicated very few failures under the Cost-Effectiveness criterion: only seven across all four scenarios. The failures concerned Urban Storage, Urban Infiltration, Morphological Coastal Protection and Reduce Coastal Energy. Within the urban zone (Chapter 3) only Urban Area Development, Operation and Form and Groundwater Control failed under World Markets and National Enterprise.

Costs will be a much more important consideration when several responses are used together, because the actual reduction in risk associated with any given addition to a mixture of responses will depend crucially on the other measures already included within it. The costs too might vary – at the extreme, some policy options may be mutually exclusive, but more generally one policy may influence both the costs and the effectiveness of another. Care will obviously be needed to avoid ‘double-counting’ of both costs and effectiveness when such interdependent policies are combined in a portfolio.

7.2.1 The cost-effectiveness of a portfolio of responses in the fluvial and coastal zone

The quantitative analysis for fluvial and coastal flooding (Chapter 5) determined the investment costs associated with achieving the new targets of standard of flood protection under each scenario in 2080. This is the additional spend required to raise today's flood defences to the required future level. It does not include land purchase or the costs of the non-engineering responses, and can thus be regarded as a lower limit. Neither does it include ongoing maintenance or periodic replacement of defences, nor the increased cost of maintaining higher defences. In order to make some allowance for the latter we show the present-day cost of approximately £500 million per year as continuing.

In summary (see Table 7.5), the capital costs (all in 2004 prices) were higher in the 'consumer' oriented scenarios, £75bn (World Markets) and £77bn (National Enterprise), than in the 'community' scenarios, £22bn (Global Sustainability and Local Stewardship). This is primarily due to differences in the target standards of flood protection (see Table 7.5), differences in the effectiveness of implementation of responses in the different scenarios, and also differences in the pattern of socioeconomic development in the different scenarios.

Table 7.5 **Fluvial and coastal flood risks and management costs, England and Wales, 2080s**

	Present Day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Flood Risks					
Baseline Case, EAD (£ m/year)	1,040	20,500	15,050	1,500	4,860
Integrated Portfolio. Target Standards of Flood Protection Relative to Present Day's	1	2	2	0.75	1
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 Costs					
Flood Management Capital Costs: England and Wales, Fluvial and Coastal; Total Cost £million		75,600	77,200	22,100	22,400
Additional Capital Costs to Achieve Risk Reduction, £ million/year		1,600	1,600	500	500
Cost-effectiveness (Benefit/Costs)		12	9	1	6
Baseline Cost £ million/year	500	500	500	500	500
Total Annual Cost (lower limit) £ million/year	500	2,100	2,100	1,000	1,000

Note that Table 7.5 does not include a consideration of the timing of expenditure, a potentially important factor. It is likely that spending in the portfolio will increase gradually rather than demanding a sudden increase in expenditure. Neither has any attempt been made to generate cost and benefit streams over time or to discount these in anyway. Instead, the total capital sums have simply been divided by 50 to take account of the asset life-cycle.

Two important points emerge from Table 7.5. Firstly, risks can be greatly reduced by implementing a portfolio of responses. Secondly, in all scenarios except Local Stewardship, the benefits in terms of risk reduction significantly exceed the costs, even bearing in mind that the cost figures quoted are lower limits.

To go further in the analysis of cost-effectiveness would require rather detailed analysis of decision-making processes over time under each of the scenarios, alongside consideration of economic and environmental changes. This would be a useful but major undertaking for future research. In the meantime the cost figures provide a very approximate indication of the different levels of physical defences required under each scenario. Furthermore, in conjunction with the cost-effectiveness ratings of the response groups, they provide a starting point for consideration of portfolios of measures which might reduce the need to spend the identified costs on flood defence infrastructure.

7.2.2 The cost-effectiveness of a portfolio of responses in the intra-urban area

For the intra-urban area we do not have such a detailed picture of the risks and costs (Table 7.6) due to the defiencies in the available methodology (see Chapter 6). However, there is again a clear demonstration that the implementation of a portfolio of responses produces a substantial reduction in risk. Similar to the fluvial and catchment zones (Table 7.5), the benefits in terms of risk reduction also clearly exceed the costs, except in the case of Local Stewardship. Unlike the fluvial and coastal zones, the portfolios of responses in the National Enterprise and Global Sustainability scenarios were more cost-effective than in the World Markets scenario. However, in this case the Expected Annual Damages is only cut by approximately half because of the non-linear relationship between flooding and the amount of water. This highlights the difficulty there will be in reducing damages within the urban zone, even with substantially increased investment.

Table 7.6 **Intra-urban flood risks and management costs, 2080s**					
	Present Day	**World Markets**	**National Enterprise**	**Local Stewardship**	**Global Sustainability**
Flood Risks					
Baseline Case, EAD (£m/year)	270	7,880	5,055	740	1,870
Residual Risks with Integrated Portfolio, EAD (£m/year)		4,200	2,400	490	720
Risk Reduction, EAD (£m/year)		3,680	2,655	250	1,150
Flood Management Costs					
Additional Costs to Achieve Risk Reduction, £million/year		540	260	400	110
Cost-Effectiveness (Benefit/Costs)		7	10	0.6	10

7.2.3 Wider costs and benefits

The cost-effectiveness considerations that we have been able to quantify are rather limited. Many factors have been excluded from the analysis, for example, relating to social impacts and the environment. Although these may have been considered in the sustainability analysis, the focus there was very much on thresholds – is it sustainable or not?

The wider costs and benefits associated with catchment-scale flooding and coastal defence take various forms (Table 7.7). Some are directly market-related. For example, managed realignment will not simply lose the value of land along the coast – partially offsetting this, land values could rise along the new coast as proximity to water features is generally highly significant in studies of property markets. Other costs or benefits could also be measured using markets, though less directly. For example, the fisheries support function of certain coastal habitats has direct implications for the economic value of fisheries. The links may be difficult to measure, and the potential values may not be realised due to overexploited fisheries, but the principle is valid. Then there are environmental goods and services with even less quantifiable market links (general ecosystem support functions, for example) or with substantial non-market links (aesthetic beauty, species conservation).

Table 7.7 **Costs and benefits associated with the five major response groups**

Response Group	Capital Costs	Ongoing Costs	Wider Benefits	Wider Costs
Managing the Rural Landscape	Yes – design, land take, construction	Yes – subsidies, administration, management costs, auditing (except for conveyance)	Potential substantial benefits – habitats, recreation, pollution control, interface with agricultural water resource use	Possible pressure on marginal land, inappropriate afforestation
Managing the Urban Fabric	Yes, probably significant	Usually minor/ moderate	Aesthetic use, recreation, habitat	Possible health impacts in some scenarios
Managing Flood Events	Minor/moderate	Yes	Communication, community cohesion, some non-flood benefits to agriculture (e.g. irrigation efficiency)	
Managing Flood Losses	Yes for some measures	Yes, also opportunity costs (land-use change)	Reduced development in floodplains, reduced non-financial costs of flooding	Equity concerns, displaced development, moral hazard – reducing the incentive for people to make adequate provisions or precautions
River and Coastal Engineering	Yes, high	Yes, small fraction of capital costs	Some potential for habitat or biodiversity benefits	Non-market values associated with land loss; environmental damage, possible habitat or biodiversity losses; altered natural processes; visual intrusion; uncertainty

Attempting to determine values for all of the effects shown in Table 7.7 would be a lengthy, expensive and difficult process even for today's policy options (see Volume I, Chapter 7). Nevertheless, some general suggestions can be made.

For example, protected coastal and riverside properties will be among those experiencing some of the greatest value increases. On the other hand, visual intrusion could be an important source of economic damage if flood defence barriers block sought-after beach and riverside views.

Recreational use values can also be very significant (over and above values to residents, reflected in property prices – see Chapter 7, Volume 1). These values will vary with preferences, incomes and provision of substitutes. One observation that might be made is that the marginal value of high-quality environments for recreation might be especially high in the World Markets scenario, where people are wealthy, possibly time-poor, perhaps not particularly concerned with environmental protection per se, but very concerned with their own consumption of environmental and other goods and services; and where economic growth may have taken a heavy toll on the number and quality of suitable environments available.

In Local Stewardship, there might be rather lower marginal values, because of greater provision and lower incomes. It is possible that these values could be significantly modified, if we consider that preferences are such that non-use values could be very high in the community-oriented worlds, in which people care about others' consumption, about future generations, and ultimately about the environment rather than as a mere adjunct to human desires.

These are just some examples of the wider costs and benefits that have not been incorporated in the Cost-Effectiveness deliberations, and which could be important. Similarly, their incidence has not been incorporated under the Social Justice criterion. One of the major impacts of most policies will be on land values (including land beneath structures, i.e., the land component of property value). For example, protecting a stretch of coast will increase the value of the land behind. Those actually using the land might not be the ones who benefit – in particular, the rental value for protected land will increase, so (after some period of adjustment) at least some (possibly all) of the benefit will pass to landowners.

The values and incidences of these wider costs and benefits in each scenario are extremely uncertain. Preferences, incomes, levels of economic activity and environmental provision are all uncertain; crucially, the physical, hydrological and ecological links between natural systems and the functions they provide us with are uncertain and often poorly understood. This underlines the importance of basic research into natural systems and the roles they play in supporting human systems.

7.3 Environmental Quality

7.3.1 Fluvial and coastal zone

Many of the more beneficial responses in terms of reducing flood risk in the fluvial and coastal zones appear to have significant environmental (and other) penalties across more than one of the four futures that are considered (see Chapter 2, Table 2.13). Coastal Defences generally fail on environmental grounds across all four scenarios, while River Defences, River Conveyance and Engineered Flood Storage fail under the more consumer-orientated scenarios (World Markets and National Enterprise).

In contrast, other response strategies appear to both reduce flood risk and have environmental (and other) benefits across the range of futures (see Tables 7.1 and 7.2):

- Catchment-Wide Storage.
- Land-Use Planning.
- Managed Realignment (at the coast).
- Morphological Protection (at the coast).

Managed realignment and creating rural storage are two of the most notable examples of this type. These two strategies also score consistently well under the other criteria (except for managed realignment and social justice). This implies that if managed realignment were to be implemented it would have to be sensitive to this issue. By implication, similar sensitivity to social justice concerns would be required when creating catchment-wide storage. The environmental benefits of such schemes, however, depend critically on the way that they are implemented. There is no automatic linkage between biodiversity and these schemes.

Related to these two strategies for enhancing natural buffers against flooding, managing exposure to flooding via land-use planning also scores highly in terms of all the criteria. Proactive land-use planning of floodplain areas would be essential to realise the full benefits of managed realignment and increased rural storage. Such planning would include:

- Identifying those floodplain areas where managed realignment and increased rural storage could have significant benefits in terms of reducing flood risk.
- Preventing new development in these areas as an immediate aim.
- In the longer term, encouraging abandonment of existing land use that limits the scope of turning these areas back to floodplain.

This implies developing an understanding of the benefits of these policies for reducing flood risk at the catchment, estuary and sub-cell/cell scale. While such research is beginning, it needs considerable development to operationalise this approach within flood management.

Morphological protection along the coast is also consistent with managed realignment, as the concept is based on large-scale manipulation of the coastal configuration to more favourable shapes that are optimum in terms of reducing flood risk. Providing space for this adjustment often implies significant amounts of managed retreat or realignment. However, again, the science base for this approach remains undeveloped and considerable research is required before flood-risk reduction benefits could be estimated and the approach operationalised. At a smaller scale, beach recharge and recycling also offer approaches that maintain natural beach habitats and maintain flood-defence functions in an environmentally sympathetic manner, although consideration must be given here to the source of the recharge material.

A key environmental threat across all four futures was identified in Volume 1, Chapter 7 as the decline of freshwater coastal grazing marsh. Most coastal grazing marshes are dependent on human management for survival, and there are limited sites for replacement habitat within the coastal zone. Hence, large net losses would be expected due to a combination of planned managed realignment and unplanned coastal-defence abandonment in all futures. However, increased rural storage along rivers via widening floodplains could provide significant areas of replacement freshwater habitats and grazing marshes in inland locations (cf. Nicholls and Wilson 2002).

Hence the four response strategies identified at the beginning of this section can be seen as complementary and offering higher environmental benefits if implemented in a long-term co-ordinated and proactive manner. While managed realignment, increased rural storage and land-use planning responses can be pursued in isolation, from an environmental perspective they would provide greater benefits if pursued together in a co-ordinated manner at the widest landscape scale. In order to achieve this it would be necessary for land-use planning to aim to preserve and enhance the space available for rural storage and managed realignment. At the same time, increasing rural storage would be a priority, creating new inland grazing marshes and related freshwater habitats before significant losses occur around the coast due to managed realignment. Sites for realignment should also take account of the potential for morphological protection. By such integration of these policies, there could be significant reductions in flood risk and substantial environmental benefits.

All the proposals that offer flood-risk reductions and environmental benefits imply allowing significant areas of land to revert to floodplain. Existing proposals for floodplain development indicate the substantial pressure on many floodplains. In areas where development pressures are highest, the benefits of these policies are potentially greatest. However, in such cases there is often pressure for more traditional defences.

Technical uncertainties may also hinder the application of some of the above policies in more developed areas where high defence standards will need to be maintained. This suggests that a wide variety of responses to managing flood risk will be applied and the approaches that yield significant environmental benefits will be more difficult to realise in developed and developing areas. Where land is at a premium, as in many coastal areas, environmental trade-offs may need to be considered between floodplain habitats and agricultural habitats in the greenbelt.

The detailed environmental implications of the above strategies are unclear, but if implemented widely they will result in significant changes to the environments of coastal and river systems. In some ways, it would be a reversion towards the environmental mixtures that existed before significant human flood management. However, these are not the current mixtures, but the changes should maintain and indeed enhance a wide range of habitats. An additional benefit of increasing rural storage on rivers would be increased base flows, which may have important benefits in terms of preventing droughts, and maintaining fluvial ecosystems in a warmer climate (see Hulme *et al*. 2002).

Finally, we note that a more strategic and dynamic approach to flood management is already emerging (Volume 1, Chapter 7). Catchment and shoreline management planning are developing a more strategic perspective of future management, and this is being integrated with environmental concerns via the CHaMPS process. Managed realignment is widely discussed within these activities and is being implemented in some trial sites (Winn *et al*. 2003). Large-scale recreation of freshwater habitats is also being considered (e.g., the Fens Floodplain Project). Hence there is increasing willingness to consider the measures presented here, including the dynamic changes they imply.

7.3.2 Intra-urban

Building Development, Operation and Form and Groundwater Control are seen as being relatively ineffective responses in terms of reducing flood risk, and are also judged to produce environmental disbenefits, although the former could be effective under two of the scenarios. In contrast, Urban Development, Operation and Form and Source Control are seen to be potentially effective in reducing flood risk in the urban area and providing environmental benefits. The latter come from controlling new development and the promotion of coherent greenspaces to increase flood storage and conveyance. They also come from the reopening of culverted water courses, the creation of detention ponds and the aesthetic use of water in the urban area through Sustainable Urban Drainage Systems (see Chapter 3). Again, we stress that the way in which these responses are implemented will be critical in determining the extent of the environmental benefits as some of the Source Control responses, in particular, have the potential to cause both environmental and health and safety problems if implemented poorly.

Inevitably, there will be problems in retrofitting a range of these measures within established urban areas. However, the preservation of greenspace, including brownfield sites, may provide good options for flood storage and conveyance for the future.

7.4 Social Justice

7.4.1 Fluvial and coastal zone

The summary statement of the social aims for sustainability is, 'Social progress that recognises the needs of everyone'. This study focuses on social justice: the impacts of options on the comparatively disadvantaged, and on future generations. The specialist teams appraising the response options identified serious concerns about the differential impact of responses on different sectors of society under some scenarios (see Chapter 2). Indeed, social justice was identified as a hurdle to sustainable flood-response policy more often than any other criterion in the fluvial and coastal catchments, in the following responses:

- **Coastal Defence Realignment**
- **Coastal Defences**
- **Reduce Coastal Energy**
- **Floodproofing**
- **River Conveyance**
- **Engineered Flood Storage**
- Abandonment
- River Defences
- Urban Storage
- Forecasting and Warning
- Collective Damage Avoidance
- Flood Fighting
- Floodwater Transfer
- Individual Damage Avoidance
- Pre-Event Measures
- Land-Use Management
- Urban Conveyance

The six responses in bold are those that are expected to be most effective in flood-risk reduction under all scenarios, but fail on Social Justice criteria in two or more scenarios. In some cases, the reason for concern about the differential impacts on poorer or more vulnerable sectors of society relates to the mechanisms for funding and uptake of the options; in others, it is linked to the impacts of the actions themselves, in particular where changes in land-use are required.

Social Justice is very tightly related to the narratives of the four scenarios. Under World Markets and National Enterprise, about half of the response options (12 and 14 of the 25 responses, respectively) failed on social-justice grounds. However, the only responses that failed *solely* on the grounds of social justice were Land-Use Management, Floodproofing, Individual Damage Avoidance, Coastal Defences and Reduce Coastal Energy. In World Markets and National Enterprise, it is assumed that individual well-being will be assured through the pursuit of national or supra-national socioeconomic aims. Measures would be taken for the national (or global) good, and would logically be focused on assets of national significance or where particular groups of national or international importance were able and willing to pay for them.

It follows that assets of national significance would be prioritised, and it implies that these assets would mainly be fixed entities or structures. Assets of low significance, or entities such as 'community' that are difficult to define, would tend to be low on the priority list for responses; and negative impacts on these assets or sectors would not be seen as socially important. We might say, taking today's perspective, that these measures are imposed unjustly on communities or individuals, but under those scenarios, it would seem eminently fair to provide flood-risk protection on that basis. The high value placed on fixed assets and the pressure to maximise economic gains in a market system would tend to encourage the use of fixed or structural defences, where the expenditure and effectiveness are most controllable.

In Global Sustainability and Local Stewardship, the underlying assumption is that national or global well-being will follow from policies that address the needs of all members of society. The focus is much more on community inclusiveness, shifting the balance away from top-down decisions about what should be part of the national asset base. Measures relying on community engagement will be more feasible, tending to self-perpetuate because they are seen as a means of assuring fairness in these scenarios.

Where fluid entities like ‘community’ or ‘fairness’ are highly valued, there is less need to be solely reliant on fixed or structural solutions to the flood-risk problem. In Global Sustainability, more regulated markets and sociopolitical systems have the scope to assure community-level well-being, rather than being led by external forces as much as in World Markets. Given that social cohesion and community well-being are priorities in Global Sustainability, it is not a surprise that no responses fail on social justice in this analysis. The two responses that fail on social justice grounds under Local Stewardship (Abandonment and Floodwater Transfer) indicate that an over-emphasis on local management can be socially divisive too, when there is inadequate scope for strategic planning and balancing of ‘winners’ and ‘losers’ associated with the measures.

From a sustainability perspective, social justice does not just address the problems of under-represented or comparatively deprived sectors of society; it considers future generations. World Markets and National Enterprise, again, are most prone to reactionism and economic ‘impatience’, and thus risk merely postponing socially divisive or damaging impacts.

Where there is concern for social justice, the clear message from this analysis is that there will be a much greater need to take account of it in the implementation of flood policies than has perhaps been necessary to date. Where this relates to the mechanisms for funding and uptake, planning, implementation and education should be carried out as equitably as possible. Where the issue relates to impacts, particularly in terms of flood risk and land use, consideration must be given to incentives and mechanisms that will reduce inequalities in terms of social justice, including relocation and compensation.

7.4.2 Intra-urban

The same issues arise in the intra-urban area in relation to social justice, but not to the same extent. Only two of the measures that were effective in reducing flood risk (Urban Development, Operation and Form and Source Control) failed on the grounds of social justice, but in this case only in the World Markets scenario.

7.5 An overview of sustainability

Tables 7.1 and 7.3 list options for flood-risk reduction with the potential to bring about a range of useful benefits, while Table 2.13 in Chapter 2 and Table 3.6 in Chapter 3 identify the options that raise sustainability concerns. It must be emphasised that although the conception of sustainability is very different under the four scenarios, it is possible in each of them. The critical differences lie in the mechanisms for achieving sustainability and the preconditions for them to work well.

In World Markets and Global Sustainability, the belief is that sustainability can be sought and achieved by 'top-down', large-scale strategic action (steered by the state in Global Sustainability, and driven by market or private mechanisms in World Markets), whereas National Enterprise and Local Stewardship emphasise local-scale decision-making, suggesting that sustainability would be constructed 'bottom-up' from many small-scale actions. The response measures analysed here range from those that require strategic vision and control (landscape-scale planning and land use change, in particular) to more locally tailored or organically evolving measures (floodproofing, damage avoidance, even abandonment). However, it is still vital to ensure that the different pieces of the puzzle do indeed add up to a coherent picture of sustainability in the more 'bottom-up' approaches scenarios.

There is tension in World Markets and National Enterprise with the time-scale for sustainability – there is little intrinsic drive to consider future generations in worlds with such an emphasis on present consumerism and individual gain. In both Global Sustainability and Local Stewardship, continuity is recognised as an important aspect of community life, and there may thus be more of a propensity to take a longer-term view. Uncertainty about the longer-term future drives the need for a precautionary approach, with two-way communication between those in power and the public, and with ongoing monitoring.

Finally, we would re-emphasise that there will be a need for engineering responses to meet the increased flood risk in all of the future worlds, but that the implementation of a portfolio of responses has the potential to decrease the cost and reliance on engineering. Where individual responses raise concerns in relation to their impacts on the environment and social justice, the key message is that it is how the responses are implemented, rather than the responses themselves, that is at issue.