of resilient materials include:

- Low permeability
- High integrity
- Ease of cleaning
- Less susceptibility to contamination
- Fast drying

Further guidance for specific building elements can be found in Soetanto et al (2008). Research shows that such installations are less disruptive and costly when undertaken as part of the repair process than as a discretionary retrofit (Joseph et al., 2011).

4.11.6. Further guidance

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Pumping out floodwater, gradually bringing down water levels in the high street, Yorkshire, UK (2007). Source: Gideon Mendel

Chapter 5

Evaluating Alternative Flood Risk Management Options: Tools For Decision Makers

Chapter 5. Evaluating Alternative Flood Risk Management Options: Tools For Descision Makers

5.1. Introduction

Chapter Summary

This chapter outlines, within a flood risk management context, the uses, benefits and, where appropriate, the limitations of existing tools and methods that can provide information to decision makers, illustrate the impacts of decisions to multiple stakeholders, and make the decision making process more transparent and accountable.

The key messages from this chapter are:

- While pros and cons of measures can be defined in purely economic terms, the judgments made by city managers, urban planners and flood risk professionals must consider broader issues, such as the vulnerabilities of inhabitants, the impact of measures, equity considerations, environmental degradation, biodiversity, sources of funding, social capital, capacity and the potential to obtain financing from third parties.
- Decisions regarding flood risk management are complex and require wide participation from technical specialists and non-specialists alike. There is clearly a role for tools which can predict the outcome of decisions, communicate risk and create linkages between stakeholders.

The impacts of flooding on cities and towns can be devastating and deadly, resulting in the need to manage the risks of flooding by governments, communities and individuals. The various measures or solutions which are available to manage flood risk in urban settings were described in Chapters 2 and 3. These methods have been successful in limiting the impact of flooding, particularly in the developed world. Urbanization, together with the observed and predicted changes in the climate, means that the solutions may need to be employed more widely to prevent the future impacts of flooding from becoming an even more destructive problem. However, despite this concern, it is not always possible or desirable to defend every urban settlement against flood risk to the highest possible technical standards. Government decisions about management of flood risk need to be balanced against competing and often more pressing claims on scarce resources as well as other priorities in terms of land use and economic development.

Decision makers and technical personnel therefore require a clear vision of the alternatives. There are now many methods and tools available to assist them in making choices. This chapter examines some of the more important of these, outlining their uses and benefits as well as their limitations in the flood risk management context.

Section 5.2 focuses on evaluating costs and benefits in monetary terms using Cost Benefit Analysis (CBA). However, city managers, urban planners and flood risk professionals must take a broader view and consider multiple aspects – some of which cannot be quantified. This need can be addressed by the use of Multi-Criteria Analysis (MCA).

Section 5.3 describes ways in which to determine the acceptable level of flood risk and to decide between alternatives, while taking account of wider policy, equity, and social issues and uncertainties.

Section 5.4 describes a variety of techniques and support systems which can be used in visualizing, assessing and communicating risk and its consequences.

5.2. Evaluating costs and benefits

Thorough assessment of flood risk should lead to more informed decision making and the selection of more appropriate flood risk reduction measures. The flood risk reduction solutions in the previous chapters provide an overview of different ways to reduce both exposure to flooding (the likelihood of being flooded) and the impacts of flooding (damage to property, for example).

The selection of the most appropriate solution (or series of solutions) is typically based on a combination of the effectiveness, cost and benefit that the solution or solutions may provide. This section will examine the methods of assessing the costs and benefits.

In conceptual terms, the reduction of risk by investment in risk reduction measures can be summed up by the term "buying down risk". As illustrated in Figure 5.1 there is a cumulative impact of investment in each measure, which results in a residual risk of flooding lower than the original risk.

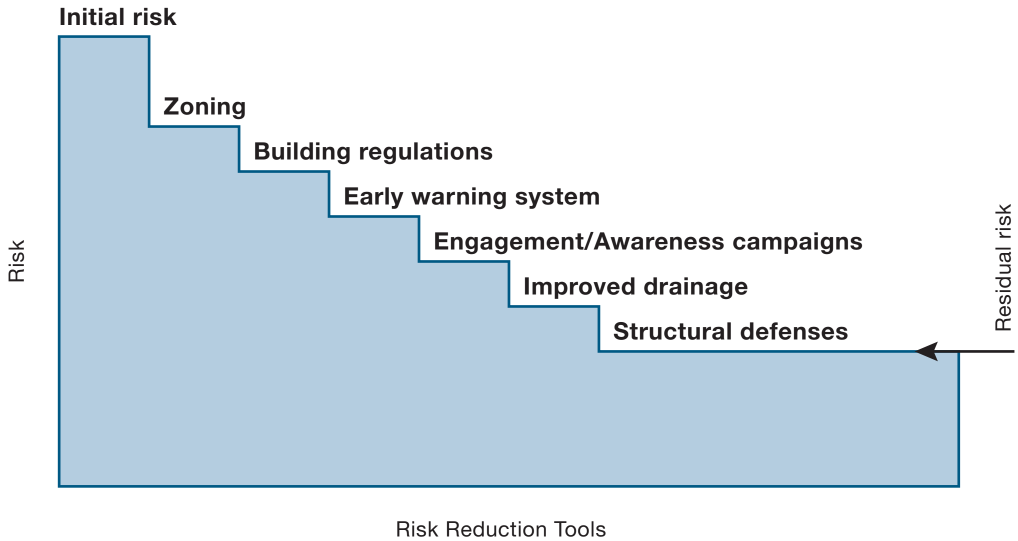

Figure 5.1: Buying down the risk. Source: Adapted from Manous 2011

It is important to recognize here that residual risk never reduces to zero; that the cost of reducing the risk may exceed the benefits of doing so; and that funds may not be available to invest in measures. Evaluation of the costs and benefits of each measure, or combination of measures, can form part of a wider strategy, which sets future targets for investment in measures and prioritizes spending on the most cost beneficial activities.

5.2.1. Cost Benefit Analysis

Cost Benefit Analysis (CBA) is the industry standard analysis tool for flood risk management measures. The purpose of CBA is to assess, over its lifetime, the monetary value of all of the costs involved in the development, construction and maintenance, and the monetary value of all of the benefits to be gained from a flood risk solution, in order to determine whether its benefits outweigh its costs. This is the main form of assessment used by decision makers to determine whether a project is worth proceeding with, and if so, when it should be started. Despite its acknowledged limitations it can be a powerful aid to decision making as illustrated in Case Study 5.1.

Case Study 5.1: Vaisigano Catchment Cost Benefit Analysis: Samoa

In 2008, a series of structural and non-structural measures proposed by the Pacific Islands Applied Geo-science Commission (SOPAC) for the lower Vaisigano catchment in Samoa, were compared using CBA.

Proposed solutions included floodwalls, a diversion channel, flood forecasting, development control and elevated construction. Avoided damages (benefits) were compared with costs including non-market costs. Data used included public records and surveys of businesses and households. Flood maps from previous events were combined with stage damage curves, and expert opinion on construction costs was obtained. The non-monetary and indirect benefits were, however, not well-captured. A 50 year life span for structural measures and 30 years for non-structural measures was assumed.

Results indicated that the most economically viable option was raised construction with a Benefit-to-Cost Ratio (BCR) ranging from 2 to 44. Flood forecasting was also found to have a BCR greater than 1. Structural measures, however, proved not to be cost beneficial. This conclusion was unlikely to be changed even if better quantification of indirect benefits was achieved.

The recommendations were that investment in flood forecasting, mapping and zoning, accompanied by zoning regulation on floor heights, should be considered, along with the possibility of grants or tax rebates to households in order to flood proof new homes. A key lesson learned was that Cost Benefit Analysis is capable of ranking both structural and non-structural solutions. Even if all benefits cannot be quantified, the differences between solutions may be large enough to give confidence in the robustness of the result.

Source: UNISDR 2009.

Table 5.1 below shows a simple example of CBA, as suggested by DFID, for use in deciding whether or not to retrofit buildings with flood proof features.

Table 5.1: Retrofitting buildings to prevent damage from floods

Potential Benefits	Methods to quantify benefits
Avoided damage to property	Value of damaged property
Avoided loss of household possessions	Compare damage to goods with and without retrofitted buildings
Avoided injury and illness	Medical expenses Loss in wages for time spent out of work
Avoided reduction in economic activity (for commercial buildings)	Loss in earnings, for example from estimated drop in customers
Avoided clean-up	Estimate the cost of labor and material for clean-up
Avoided emergency services costs	Necessary provision of equipment and people Incident specific costs (staffing, fuel, materials)

Source: Adapted from DFID 2005

The list of possible benefits and costs that might be considered for an urban flood risk management project, including direct and indirect benefits, could be very lengthy. Costs are usually easier to identify and evaluate – and it is important here to consider lifetime costs including maintenance and upgrading. Depending on the project, these might include:

- Assessment of risk and potential measures
- Design of measure
- Implementation and capital cost
- Resettlement costs where large land use changes are involved
- Maintenance including the setting up of systems and institutions to handle maintenance
- Cost of secondary measures, e.g. meteorological forecasts required to enable an early warning system or necessary measures on tributaries when large barrier systems are installed
- Restoration or rehabilitation of surrounding areas
- Disruption of traffic and trade

- Replacement or upgrading costs if the reversal of
  the measure would not be possible
- Ecological loss for example in large conveyance or storage projects.

For different types of measures, the benefits could be similarly broad and far-reaching, particularly for those non-structural and greening measures that are designed to integrate into urban planning and management. There may be many distributed benefits from flood risk reduction measures, not just a reduction in damages. For example, the provision of a floodwall may provide protection to an area of land, enabling this land to be used for urban development, or for infrastructure, such as a highway. It may also increase safety, reduce insurance premiums, and reduce building code requirements and encourage investment. A flood relief channel may be used for recreation, commerce and environmental management, thereby increasing business and tourism. It could also increase the value of property along the waterfront, and by providing recreational space, improve the quality of life, reduce the urban heat island effect and permit higher density development in adjacent areas. The list of benefits might also include:

- Reduction in loss of life
- Reduction in physical damages
- Reduction in commercial losses due to business interruption
- Reduction in emergency costs such as evacuation and clean up
- Increased development potential of protected areas
  and potential for inward investment
- Reduction in health effects such as medical expenses and lost work time
- Improved quality of life, lower stress
- Maintenance of biodiversity, ecosystems, carbon sequestration
- Reduced Urban Heat Island impacts leading to lower energy consumption
- Increased leisure amenities, tourism generation
- Increased hydro-power generation
- Increased technical capacity of population and higher levels of education.

No list can be wholly comprehensive, and it is part of the evaluation process to identify the various costs and benefits that are relevant for individual cases. The measurement of benefits is usually much less certain than that of costs for two main reasons. First it involves a measure of expectation of future losses which, given the probabilistic nature of flood forecasts, could be far from the actual avoided loss. Second the wider benefits may not materialize due to unexpected consequences and interactions with urban environments and management practices. For example, the commercial development potential of a newly protected site may not be realized due to economic downturn, non-completion of associated infrastructure, or the sudden availability of other development sites nearby. Given the long lead and life times for flood risk management projects many assumed conditions can change. The relative weighting between direct and indirect benefits varies between flood scenarios. There is some indication that the larger the flood event, the higher the proportion of indirect losses due to massive disruption. Other influencing factors include the level of development and insurance penetration (Mechler. 2005). Therefore for some projects (and some types of benefits in particular) the total benefits will be difficult to quantify. If the anticipated benefits are widely distributed, hard to quantify or uncertain, sensitivity analysis is crucial to assess under which circumstances the decisions would change.

The scale of the CBA is also critical. At the scale of the national economy, and in the long term, it may often be seen that a natural disaster boosts an economy and therefore prevention has a lower payback than at a more local level, where the economy suffers severely in the short term. Therefore, evaluations must be both scale and time relevant; the scope and objective of evaluation must also be defined. Projects and activities funded from city revenues, for example drain clearance, should provide a local benefit. Large catchment storage and conveyance schemes might benefit the whole economy. The benefits to the wider economy are naturally more difficult to quantify, but may make a significant difference to the evaluation of different projects.

Photo 5.1: Recreational use combined with flood relief channel and new dyke, Netherlands, Source: Baca Architects

To fully realize the potential power of CBA it is necessary to represent costs and benefits in monetary terms. A number of analytical mechanisms have been developed to attribute value to environmental and social issues, thereby describing them in economic terms such that they can be incorporated into traditional CBA. Broadly speaking, these can be described as one or the other of two approaches:

1. Valuation – such as assessing economic value based on an associated cost (such as house prices or the cost of travel)
2. Pricing/costing – such as assessing the cost of alternatives (such as the cost of replacing the lost environment, or the cost of an alternative to it).

Both of these approaches are based on 'use value' and 'non-use value' to people, as seen in Figure 5.2. Sometimes it is difficult to attribute a human use value to the environment. The environment, nonetheless, may be considered to have value on the basis that it is attractive to look at; or it is the habitat of rare species; or it has historic importance; or people would be disappointed if it were gone; or it might have a potential benefit in the future, such as undiscovered medicinal plants.

These methods focus on the value of the environment to people. Consideration of non-use value may need to be applied to the value of other components or creatures in the ecosystem, and which in turn may support that ecosystem.

It is worth noting here that our understanding of the value of the environment to people is continually improving: for example, we now know more about how wetlands can reduce storm energy and enhance water quality. Over time, there may be fewer and fewer non-use values, making the analysis of the benefit from the environment clearer.

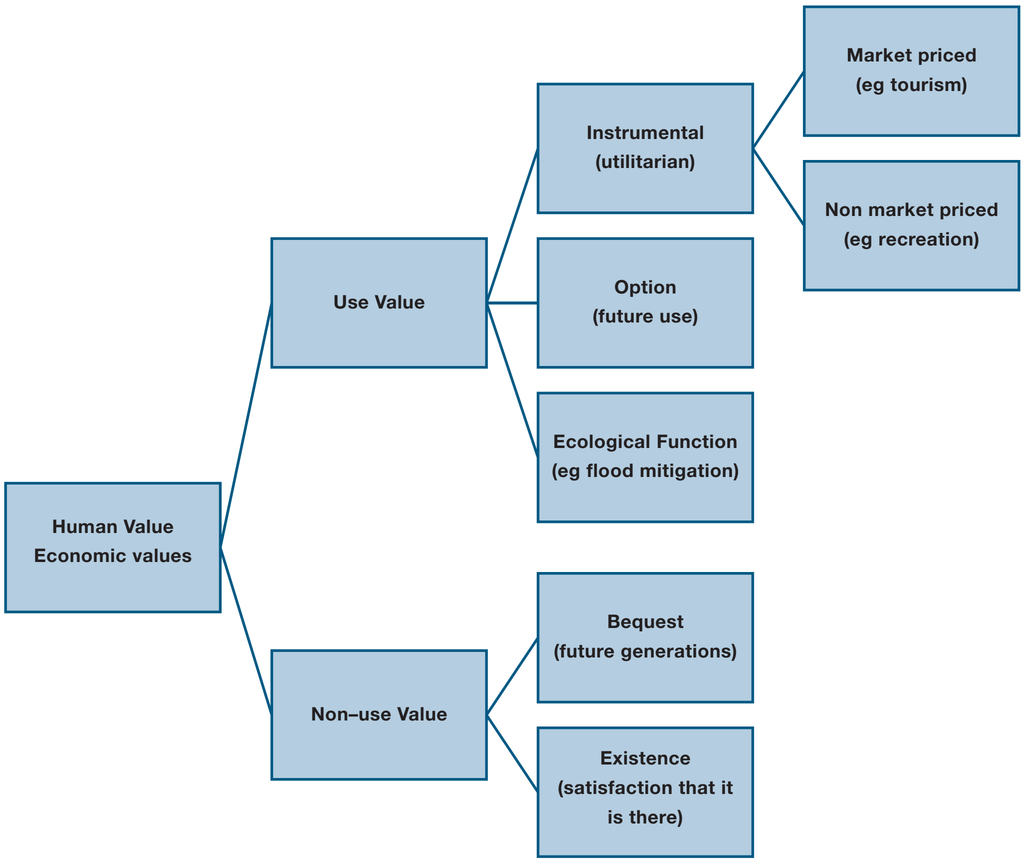

Figure 5.2 : Environnemental values. Source: Adapted from Lamond and Bateman 2012.

The uncertainty of climate change predictions has also begun to influence the assessment approach. There is a need to explore a range of outcomes and solutions to provide robust decision-making, which increases the reliance on 'valuation' assessment (which is based on theory) over 'pricing' assessment (which is based on an understanding of past value or cost).

An alternative or sometimes additional complementary approach to such quantification is to use a supplementary analytical tool such as Multi-Criteria Analysis (MCA), which is discussed below. This may be used to assign formal scoring and weighting to various options, which can then be ranked.

5.2.1.1. Evaluation techniques

Typically, CBA is used to test the economic viability of a specific flood risk measure, using one of the following basically equivalent assessment techniques:

- Net Present Value (NPV);
- Benefit Cost Ratio (BC); or,
- Internal Rate of Return (IRR), effectively the efficiency of the investment.

This method of analysis assumes that the flood risk solution being considered has already been determined. The aim of the CBA is to assess whether or not it merits implementation and at what time it is best to implement. The three evaluation techniques indicated above are now briefly described.

Net Present Value (NPV) is a mechanism for adjusting the simple benefit minus cost calculation to take into account the future value of cash flows over the lifetime of the project. The NPV is the value of the project (benefits less costs) after the ongoing costs and benefits in current money are discounted to present day values. The discount value is often taken to be the 'opportunity cost' of not investing the money in alternative schemes (this could be the cost of borrowing, or the average return rate on capital investment). If the NPV is positive, then the project is considered desirable. NPV is particularly relevant to large structural flood risk solutions, which are likely to incur the majority of the project costs early on, while benefits may only accrue over time. Incremental non-structural measures, on the other hand, may delay costs while still delivering benefits early on. If several options are to be considered, the one with the highest NPV is normally selected.

Benefit Cost Ratio (BCR) is a different way of representing this discounted cash flow picture. Rather than taking the difference between the costs and benefits, the BCR takes the ratio of the discounted value of the benefits to the discounted value of the costs. A BCR of one is equivalent to an NPV of zero (the breakeven point). Some governments and organizations set a minimum BCR ratio for a project to be eligible for funding.

Internal Rate of Return (IRR) is a mechanism for identifying the maximum discount/ interest rate at which the project is still economically viable (that is, the point at which the NPV is zero), which can be viewed as a project yield on investment. If this rate exceeds the government rate of return on capital then the project is seen as desirable. IRR is not considered to be the best method for ranking projects as the interpretation of maximum return rates is complex.

CBA can be used to help assess whether a flood risk measure is cost effective, or which of the flood risk solutions being considered are the most economically efficient. It can also help with ruling out options. CBA is most effective when compared with a 'do nothing' scenario or 'without' the flood risk solution scenario. Table 5.2 illustrates the five initial policies explored in relation to the UK's Thames Estuary 2100 project, the first of which is the 'do nothing' scenario.

Table 5.2: Various policies examined by TE2100 project

Policy P1	No active intervention 'walk away'
Policy P2	Reduce existing flood risk management actions (accepting that flood risk will increase over time)
Policy P3	Continue with existing and alternative actions to manage flood risk at the current level (accepting that flood risk will increase over time from this baseline)
Policy P4	Take further action to sustain the current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change and climate change)
Policy P5	Take further action to reduce flood risk (now, now and in the future, or solely in the future)

The evaluation of the 'do nothing' scenario helps to determine the negative impact of flooding if no flood risk management solution is implemented. When combined with other analytical tools to assess environmental and social benefits such as MCA, CBA can provide clear direction on which flood risk solution should be implemented – and when. This further helps to provide assurance to institutions to facilitate planning, financing and development.

5.2.1.2. Distributional impacts and equity

A limitation of CBA is that traditionally it has been unconcerned with the distribution of costs and benefits: for example, it neither considers who pays for the risk reduction measures, nor who benefits from them. Also, by taking as its basis the economic costs and benefits, it artificially weights the preferences of the wealthy over those of the less well off. Flood defenses will be provided more to the rich because the assets of the rich are greater and therefore the damage prevention potential within wealthy neighborhoods is much greater than that in poorer ones. Similarly in contingent valuation studies, the rich will be, on average, willing to pay more for risk reduction because they are able to. Some methods for valuing a life will rank a high earning individual above a low earner or non-worker.

This aspect of CBA has serious equity implications: The low average economic status of individuals in developing countries will tend to mean that all interventions are less economically beneficial than they are in developed nations. Unless costs are commensurately lower in developing economies, fewer measures will be able to be justified on a cost benefit basis and the population may be less well protected as a result. It may be important therefore to control costs by the use of locally based resources and labor and to consider competing projects within the context of development goals rather than economic return. Within individual countries it is the poor who will struggle most to justify funding to protect themselves and their property. Those who are economically inactive (for example women and children) and also often most vulnerable, will also be disempowered and may have their needs ignored. Decision makers should be made aware of these limitations and of methods to overcome it, such as vulnerability weighting and approaches which look at costs and benefits relative to income.

There is also a density aspect to costs and benefits such that widely distributed assets tend to display a lower CB ratio; the urban and rural poor, whose assets are low level but also sparsely distributed, will rarely qualify for any risk reduction spending if CBA is strictly adhered to. The Mississippi River floods of May 2011, discussed in Chapter 3, provided an illustration of a situation where highly populated urban settlements were protected by the deliberate direction of floodwater on to less populated rural land and settlements. While this may be justified on economic grounds, and planned well in advance, it can still be viewed as unjust.

The source of funding can also have distributional implications. Usually, solutions are paid for by taxpayers out of general taxation, which will have a redistributive impact but may be seen as unfair by those who live in areas which are not at risk. Methods can be employed to adjust for these issues if they are recognised but frequently they are ignored or not explicitly considered.

5.2.1.3. Sensitivity Analysis

Many of the assumptions necessary to perform a CBA such as the discount rate, expected project costs, or future flood probability may be rough estimates, uncertain, or politically motivated. Sensitivity analysis is designed to test the robustness of CBA to changes or inaccuracies in assumptions, or project overruns, amongst others: for example, in a CBA in Peru, the IRR varied from 12 percent to 30 percent when assumptions were changed (such as not taking account of loss of life). In this case, however, the IRR was above the required threshold under all assumptions (ISDR 2009). In another example, sensitivity analysis of a World Bank flood control project in Taiz, Yemen, found that the evaluation is most sensitive to increased construction costs and reduced damage costs (World Bank 2001).

5.2.2. Multi-Criteria Analysis (MCA) of cost benefit and socio-environmental issues

MCA is a complementary approach to incorporate less formal consideration of social and environmental issues into project evaluation. MCA is used to balance the needs of multiple stakeholders and to allow consideration of costs and benefits that do not ordinarily have an economic (market) value, such as biodiversity, well-being or community spirit, as Case Study 5.2 demonstrates. MCA provides a framework for attributing importance to the functions of such items; equally it encourages decision makers to consider these items where they may not otherwise do so.

Case Study 5.2: Cost-Benefit Analysis for Community-Based Disaster Risk Reduction in Nepal

A disaster risk reduction project to help selected communities address the adverse impacts of annual flooding was carried out by Mercy Corps Nepal and the Nepal Red Cross Society between 2007 and 2009 in the Kalali District in western Nepal. Floods and other weather-related hazards in Nepal are a major factor contributing to poverty. This is likely to increase due to climate change and variability.

The Kailali Disaster Risk Reduction Initiative (KDRRI) was implemented in six communities. The aim of the project was to increase the resilience of those communities through DRR. The project which was implemented in collaboration with the communities, the local government and other key actors, included measures such as capacity building and training, early warning systems, small-scale mitigation, education, and facilitation of coordination. At a second phase, the project expanded these activities to 10 additional communities.

The cost effectiveness of the project was assessed by employing social science research methods (such as structured surveys, field visits and interviews) for data collection, in combination with a computerized mathematical model, for data analysis.

The project yielded a B:C ratio of 3.49. This means that for every USD 1 spent, there is USD 3.49 in economic benefits. These benefits represent the prevention of economic losses or the avoidance of otherwise necessary humanitarian assistance. This B:C ratio, however, does not include the qualitative benefits of the project. Qualitative analysis found that the KDRRI project provided significant economic, social, and environmental benefits that were difficult to quantify. These benefits were associated with increased social cohesion, education, empowerment, saved lives, and indirect impacts on economic capital. If the qualitative benefits were included, the final B:C ratio would have been significantly greater. The experience demonstrates that community-based measures are in fact very effective in reducing flood risk and have a high payoff.

Sources: White and Rorick 2010.

MCA aims to establish the goals and objectives of all of the stakeholders that may be affected by both the flood risk and the associated risk reduction measure. Consensual weighting is then determined for various elements, through discussion with stakeholders. Table 5.3 below illustrates how MCA was used to provide weightings to six categories being assessed for a flood warning system in Scotland.

Table 5.3: MCA weightings used in SNIFFER UKCC10B, Source: Halcrow 2009.

Category	Weighting
1) Risk to life and serious injury reduction	30%
2) Social impacts reduction	20%
3) Residential property damage reduction	15%
4) Business and agriculture damage reduction	15%
5) Flood defense operations improvement	15%
6) Infrastructure disruption reduction	5%

This weighting was then used to assess the benefits to different areas within the river catchment for potential flood events, as shown in Figure 5.3.

Benefits

Return period (yr)		☐ 10	☐ 50	☑ 200	Average
Category	Weighting (0–100)	Score (0–100)			
1 **Risk to life/serious injury reduction**	**30**	**15**	**100**	**100**	
2 **Social impact reduction**	**20**	**90**	**100**	**100**	
3 **Residential properties damage reduction**	**15**	**40**	**100**	**100**	
4 **Business/agriculture damage reduction**	**15**	**24**	**48**	**57**	
5 **Flood defence operations improvements**	**15**	**19**	**8**	**0**	
6 **Infrastructure disruption reduction**	**5**	**8**	**100**	**100**	
Total	**100**	**35**	**78**	**79**	**18**

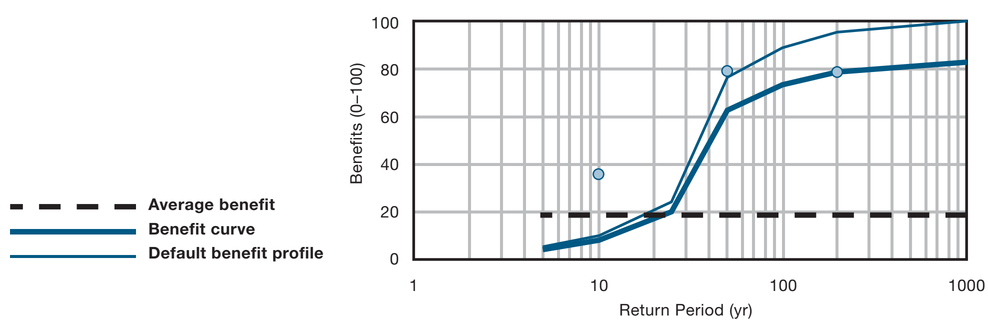

Figure 5.3: Benefit profile for 0.05 percent flood event, Source: Adapted from Halcrow 2009.

The weightings used in MCA are consultative and derived from stakeholders. This implies that the weightings are subjective and anthropocentric, and that they may be based on ill-informed judgments. These weightings would be quite different for a different project, or for one in a different location, or as a result of political or social factors or changes. It is vitally important to gain representation from a sample of all stakeholders and to brief them thoroughly on the purpose and details of the proposed schemes. However, they illustrate a particular weighting that was reached by agreement with the key parties in a particular instance.

The multi-actor participation explicit in MCA, and the need for buy-in to the weighting analysis and results, means that transparency and public involvement from an early stage are essential. Public involvement may also require better communication of issues that are difficult to grasp, together with a clear explanation of the analysis process.

5.2.3. Operation and maintenance cost

One of the most important considerations when evaluating the costs of a project is the cost of operation and maintenance (O&M). If flood risk solutions, particularly those that are structural, are not maintained then it can fail at the time the solution is required to provide protection. This can increase the risk more than if the solution did not exist: not only by giving the residents a perception of protection but also by undermining the need for evacuation planning or other measures.

CBA and MCA can include such costs without difficulty, but estimating the costs of operation and maintenance through the lifetime of the solution may be difficult. Several factors could influence this – inflation, increased wealth, or the shortage of a workforce, amongst others. Often the O&M costs will be underestimated relative to the initial costs. Furthermore, even if the costs are identified it is important to identify the responsibility for and the source of this money. Is it provided upfront and set aside? Will the government provide it? Will private industry, such as the insurance sector, provide it?

There are many reasons why O&M may not be continued after a project is completed. But if there is a serious risk that it will not be continued, then it may be preferable to use non-structural measures.

5.3. Determining the appropriate level of protection (ALARP)

As discussed above, CBA, incorporating MCA as necessary, are very useful tools in ranking alternative solution sets for flood risk. However, such analyses are limited in that they can only rank the alternatives suggested – and that they do not provide a final decision as to whether or not to undertake measures.

Governments have limited resources and will often choose not to implement schemes which may be cost beneficial because of the lack of available funds to do so or because there are other priorities which take precedence. This is true in developed countries, such as the UK, where many more schemes pass the cost benefit threshold than can be immediately funded. It will also apply in developing countries where resources may be much more limited, or may depend on international donors with their own agendas to satisfy.

As discussed above, economic analysis in general will struggle with concepts of equity and distributional effects and with the quantification of environmental and social impacts. For the analysis of flooding, the quantification of the value of a human life may be a key deciding factor. This seemingly simple concept is fraught with emotional difficulties and subject to value judgments, which economic models cannot make. Flood risk reduction solutions will usually benefit some stakeholders and disadvantage others. The decision of what is fair or equitable is not easy to make. Another issue in decision making in the era of climate change, is the huge uncertainty associated with future predictions of flood patterns.

In practice, although governments of the developing world are largely responsible for determining the level of spending on flood risk management as opposed to say, education, they do not do so in isolation. The fact that, in democracies, it can be observed that response to natural disasters is correlated to re-election campaigns is clear evidence that governments are very mindful of public opinion, as well as the views of (or pressure from) the wider international community (World Bank and the United Nations 2010). There is some evidence that both voters and donors are more prepared to accept risks from natural hazards rather than anthropogenic hazards; it seems they also prefer spending on relief to prevention. This could be a result of cynical self-interest, some element of moral hazard, or lack of belief in the ability of government to control nature.

Increasingly, if individuals and nations rely on insurance or risk markets to finance reconstruction, then the demands of insurers and capital lenders may become increasingly important in determining the appropriate level of flood protection. This is the case in the UK where the current informal ‘gentlemen’s agreement’ between the insurance companies and the government provides no guarantee of cover for those with a probability of flooding which is greater than 1.3 percent (or 1 in 75), unless plans are in place to reduce the flood risk below the threshold within five years (although it is still profitable for insurers to provide cover to some households above this risk threshold).

5.3.1. Defining ’target protection’

Target protection levels may be an attractive notion but very few countries have a published target for protection levels of their population. The Netherlands is an interesting case: structural defenses are designed to protect the population within the dykes to against a 0.0001 percent (1 in 10,000 year event). The expected impact of climate change means that the standard is being re-examined. The very notion of target protection is difficult to define in a situation where structural defenses are being replaced by non-structural measures such as land use planning, early warning and evacuation. Protection ceases to be a promise to keep people and assets apart from water and moves towards a language of minimising expected losses.

5.3.1.1. The As Low As Reasonably Practical (ALARP) principle

In deciding on an acceptable level of risk for populations to bear, the concept of ‘As Low As Reasonably Practical’ can be adopted. With this approach, the acceptance of risk can be expressed as a three tier system which requires definition of:

- An upper band of unacceptable risk
- A lower band of broadly acceptable risk
- An intermediate band of tolerability which is tolerable if risk reduction is impractical or the CB ratio is close to one.

This is illustrated in Figure 5.4.

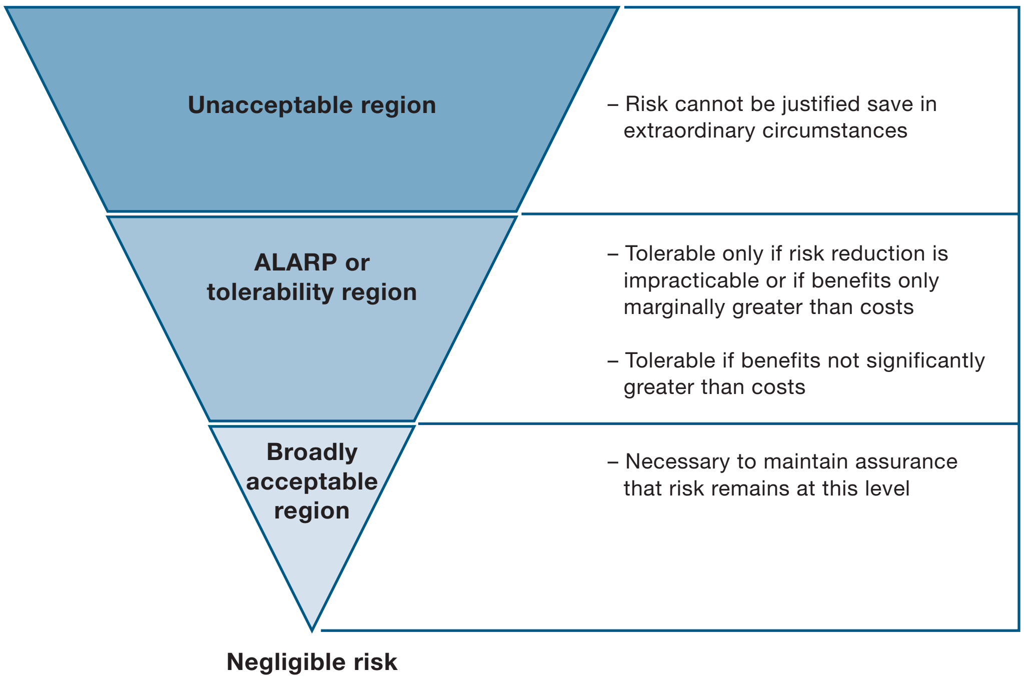

Figure 5.4: Acceptable levels of risk and the ALARP principle, Source: Adapted from FLOODsite 'Language of Risk.'

This conceptual framework is useful as it allows for some fixed decision points, without being completely deterministic. However, in the field of societal risk (rather than the industrial sphere from whence the concept came) defining the bands can be problematic, as consensus between stakeholders is unlikely to be easily reached.

Attitudes and tolerance to risk can be measured via the use of revealed and expressed preference methods; so too can the appetite of populations to pay to reduce the risk. In the context of flood risk management, expressed preference methods may tend to under-estimate risk tolerance due to the game playing of participants. Revealed preference may fail to detect risk aversion due to inertia, low income levels and lack of alternative choices.

5.3.1.2. Opportunity cost

Governments must also consider the 'opportunity cost' of flood risk management spending. Opportunity cost here refers to the cost of not doing something else with the money spent on flood measures. The money might be more usefully spent in protecting against other disasters or in education or health. In theory, governments could evaluate all possible uses of the money allocated to flood risk management and rank them in order of importance. In practice, no government would want to allocate funding on such a basis, or be able to evaluate all the potential spending priorities in enough detail to do this. However, opportunity cost is a useful concept in decision making, such as when using a comparison of average CBA ratios across government departments to inform programs.

5.3.1.3. The value of a life

Difficult as it may be to accept, in order to make cost benefit decisions in flood risk management, a valuation of a human life is often employed. It is a particularly important figure in the benefit analysis of evacuation schemes, which may not provide much damage reduction, but do save lives. The method used is usually referred to as Valuation of a Statistical Life (VSL) (World Bank and the United Nations 2010). Recommended VSL figures range from US$ 4 to 9 million for the US and from US$ 0.8 to 74.1 million for other countries (Wang and He 2010).

There are paradigms available to assist in this valuation, such as the expected future earnings, or the economic contribution of an individual, or the replacement cost of the investment in health care, education and social welfare that the state has provided. Insurance models may also be useful. Under such paradigms, relatively wealthy economies will naturally value a life at a higher rate than less wealthy ones and VSL will be related to average income. This often leads to very low valuations in the thousands of dollars for developing economies. Contingent valuation methods generally yield higher values: a recent Cambodian study for landmine clearance gave an estimate of US$ 0.4 million. Within a nation, regional, gender and ethnic differences may also apply.

It can therefore be seen that the choice of method of value for VSL is a critical issue for project evaluation and that even attempting to rank different solutions may be dominated by the choice made. Sensitivity analysis on this variable is therefore usually warranted.

5.3.1.4. Demands of insurability

Commercial insurance is most available to cover residual risks which conform to insurance principles. In order to diversify their portfolios, reinsurers rely on a range of international businesses with risk profiles that complement each other.

Attractive propositions rely on known risk profiles and simple triggering events. To offer the security that the risks are covered up to a given level of return, either by defenses or by internal funds and practices, and to allow the insurer to pick up the risk for extreme events may involve an externally determined target level of protection.

In the UK the 'gentlemen's agreement' referred to above, also known as the 'statement of principles' (ABI 2008) sets a 1.3 percent (1 in 75 years) target level of protection. Defenses constructed to a lower level of protection will leave the residents and businesses at risk of being uninsurable. This insurance-set standard has the potential to create the minimum and maximum level of protection, with little incentive to exceed this target without further government regulation.

5.3.1.5. Benchmarking and regional cross-cooperation

Governments may benchmark their performance against other similar economies or near neighbors. On a practical level this could be in order to attract inward investment, secure livelihoods and promote economic growth on a par with other countries. Alternatively, if risks are pooled regionally, or there is cross-border cooperation on mitigation or relief operations, then parity in protection levels may be part and parcel of negotiations.

As a simple example, if a river basin crosses national boundaries, it may be incumbent upon nations downstream to protect to at least the level of their upstream neighbors, but possibly not to greater levels.

5.3.1.6. Decisions under uncertainty

Uncertainty can lead to indecision. Where investment in flood defenses and infrastructure is designed to last well into the long-term future, the range of possible future climate scenarios (discussed in Chapter 1 of this volume) is unlikely to be addressed by one optimum solution. Decision makers are nervous of:

- Over-adaptation: where adjustments are proven to be unnecessary given the climatic conditions that actually occur, such as a sea defense built to withstand four meters of sea level rise that never emerges.
- Inaction or under-adaptation: a failure to act, or where adjustments do not achieve the maximum potential reduction in losses for the realized climate, or in some cases actually increase impacts above what they could have been, given improved anticipatory adaptation.

– Incorrect adaptation: where adjustments are made but are later found to be either not adaptive or counter-adaptive.

Robustness, that is finding alternatives that perform well under all scenarios, then becomes a preferred strategy rather than finding the optimal solution. An optimal solution might perform well in most scenarios but be disastrous under some assumptions, bearing in mind that the ALARP concept may ensure that robust solutions do not result in risks in the intolerable band. Figure 5.5 illustrates the trade-off between cost benefit and robustness and shows that some measures (e.g., early warning systems) perform well under both judgment criteria while others (e.g., hard-engineered defenses) may be better on one criterion but perform poorly on others.

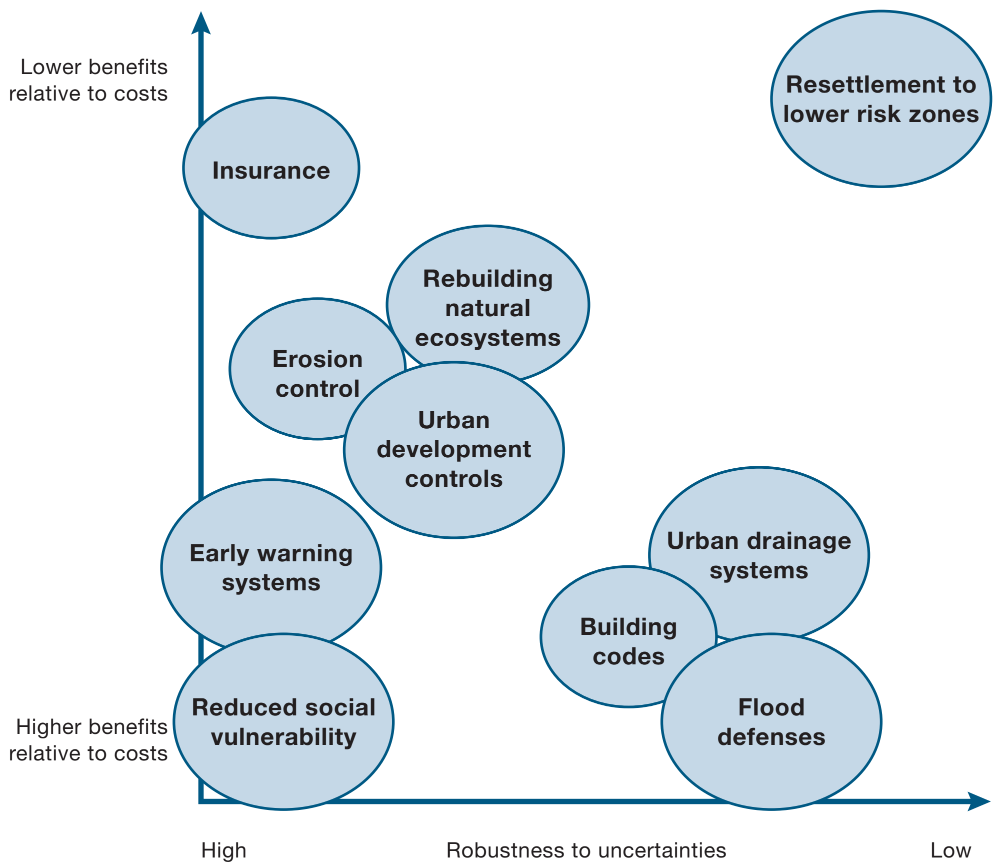

Figure 5.5: Relative costs and benefits of flood management options.Source: Adapted from Ranger and Garbett-Shiels 2011.

Robustness can be achieved by means of a variety of strategies, depending on circumstances and the urgency with which decisions need to be made: flexible solutions; 'no regret' solutions; the precautionary principle; planned redundancy (‘just in case’); and ‘wait and see’. In the developing world it has to be recognized that the urgency to make robust decisions is high: as urbanization and urban development proceed, infrastructure needs to be planned and large populations need to be protected. This will lead to a preference for the flexible, ‘no regret’ and ‘just in case’ approaches. In contrast, the developed world may be able to delay making changes to the already existing settlements and infrastructures.

5.3.1.7. No regret solutions

Measures which will be cost-beneficial regardless of changes in future flood risk are often termed ’no regret’ measures. These measures usually have some of the following features:

- Are low cost, and are therefore likely to have a high CBR whatever happens
- Have benefits other than flood risk management
- Are part of a wider program that contributes to development
- Are not sensitive to changes in future flood risk.

Examples of such approaches are forecasting and early warning systems: these are not sensitive to future flood risk and are relatively low in cost to set up. Informal settlement upgrading or clearance by rivers also has many benefits over and above the flood management role; restoring wetlands may also have amenity value.

Box 5.1: Early Warning Systems

Early Warning Systems save lives and can have extremely high payback relative to cost. If people are aware of a risk beforehand, and receive a credible and trusted warning in sufficient time to evacuate to a place of safety, many lives can be saved. Weather forecasts, warnings, and emergency responses associated with hurricanes in the US are valued at US$ 3 billion per year (two-thirds of this from reduced loss of life). The value of public weather forecasts to households in Ontario, Canada, is estimated at US$ 1.26 billion per year (Jha and Brecht 2011). A pilot study in Russia found a payoff of US$ 4–8 for every US$1 invested in modernization of hydro-meteorological services across the country.

After super-cyclone Bhola killed more than 300,000 people in 1970, the Government of Bangladesh in partnership with the Bangladesh Red Crescent

Society established the Cyclone Preparedness Program in 1972. Working with local communities, a system appropriate to the area was developed to transmit hazard warnings based upon radio broadcasts complemented by flags of various colors, hoisted where they would be easily visible.

As part of a comprehensive, end-to-end mitigation, warning, evacuation, and sheltering system this led to a dramatic drop in deaths and property losses from cyclones in that country. Another good example is the China Meteorological Administration's Weather Alert Service via SMS which reaches more than 90 million users.

The urban poor are, however, more likely to take increased risks to secure housing and property during disasters, in spite of functioning early warning systems. Cities are, therefore, likely to require targeted communication strategies to reach out to these communities. A good example is the Jakarta Flood EWS, which has a strong focus on the community capacity building element and ensures the coordination of activities between front-line providers (such as NGOs and community organizations) and local governments.

Source: Jha and Brecht 2011.

5.3.1.8. Flexible solutions

Flexible solutions are those which can be adapted to changing futures. Although changes may be necessary in the future as risks change, flexible solutions allow for that change without major reinvestment or reversal of earlier actions. Many non-structural measures tend to be inherently flexible, for example early warning systems or evacuation plans. Structural measures are seen as less flexible, but flexibility can sometimes be incorporated, as seen for example with the installation of wider foundations for defenses so that they can be raised later without having to strengthen the base. The purchase of temporary flood defense barriers can also be seen as flexible, as they can be deployed when and where necessary as flood risks change.

5.3.1.9. Decision Trees

Decision trees or decision pathways are a commonly used decision- making aid in many fields. The concept works by assessing options against various appraisal criteria at different points in the future and identifying thresholds (or 'tipping points') for each option. It is then possible to lay these options out in a temporal sequence, mapping the point in time when each tipping point is expected to be reached. Their advantage, when considering future investment in flood risk reduction in an era of climate change, lies in their ability to reflect probabilistic scenarios in a transparent way. The highly-structured nature of the approach should ensure that all contingencies are considered and that timing and uncertainties in decision parameters are clarified. The use of such methods is illustrated in Case Study 5.3 where the future of the Thames Barrier was assessed against potential sea level rise.

Case Study 5.3: Flexible planning: Thames Estuary 2100

The Thames Estuary 2100 project (TE2100) developed a long-term tidal flood risk management plan for London and the Thames Estuary. Walls, embankments, barriers, gates and other flood defense structures already exist to provide protection against flooding from the sea. Protection against flooding from upstream is provided by walls along the River Thames, and walls, culverts and local flood storage along tributaries. In most areas these structures were designed for a flood level of a 1000-year event, while for some less developed areas, lower standards were adopted.

These flood defense structures will reach the peak of their design lives over the next 20 to 30 years due to gradual deterioration. This, along with the potential increase in frequency and severity of flooding due to climate change and socio-economic change, has led to the development of the TE2100 project. The project identifies adaptation options and pathways under a range of climate and socio-economic scenarios in order to respond to future uncertainties.

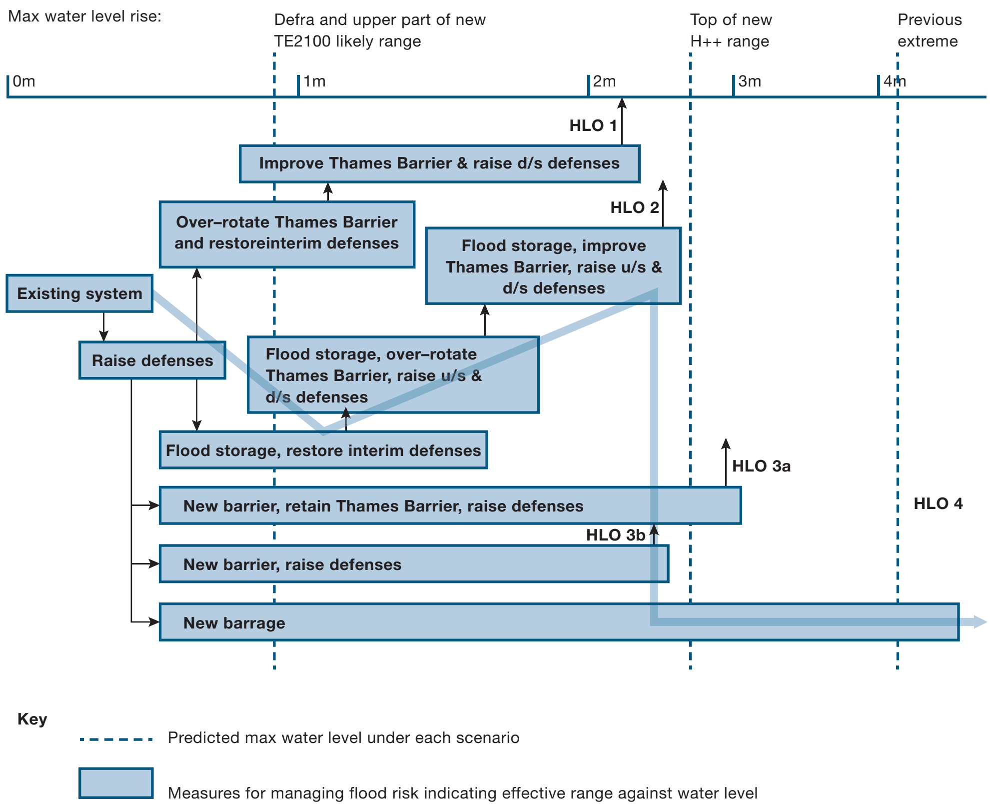

Figure 5.6: Adaptation options and pathways developed by TE2100 (on the y-axis) shown relative to threshold levels increase in extreme water level (on the x-axis). The light grey illustrates a possible 'route' that decision makers would initially follow if sea level was rise faster than predicted. Source: Adapted from Reeder and Ranger 2011.

Uncertainties in future flood risk projections and the high sensitivity of decisions about climate change, all make urban flood management planning a challenging process. The TE2100 project developed and applied a framework for adaptation planning that ensured that adaptation strategies would be cost-effective in reducing risk, while being flexible and adaptable to future uncertainties.

Sources: Ranger et al. 2010; Reeder and Nicola 2011; Defra 2009; Environment Agency 2009.

5.3.2. Consideration of the worst case scenario

For most decision making purposes the standard decision tools focus on the most probable events and plan to deal with scenarios on or around the average expectations. Probability theory and experience both point to the need to also consider the worst case scenario. It is a truism to say that a “one in a million event” is almost certain to happen eventually. While the unthinkable happens rarely, the consequences need to be thought through. Judgment will be required to define the exact worst case scenario to be considered.

Worst case scenarios can also often be triggered by failure of systems, it is not necessary to determine how likely a system is to fail to know what will happen if it does. Systems should be planned to “fail gracefully,” or as gracefully as possible, in order to minimize the damage from the worst case scenario.

Equally worst case scenarios can be generated by extremes of weather well outside the expected patterns. Defining the worst case is more problematic here as the definition of possible weather events is infinitely variable. Often it is only necessary to contemplate a weather event outside the design capacity of the system. Alternatively an event causing total destruction of a settlement could be considered.

Whatever the scenario, the importance of the discipline of considering the worst case is to prevent complacency and over-reliance on solutions.

Benefits might include:

- To plan for failure
- To avoid solutions which might make a man-made disaster worse than the natural event
- To make long term strategic decisions on placement of key infrastructure
- To highlight the importance of integrating a set of structural and non-solutions
- To demonstrate the importance of flood risk management investment as against other priorities.

Visualization and simulation tools such as those described below can be very useful in this regard.

5.3.3. Further reading

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Defra. 2009. "Accounting for the Effects of Climate Change." London: Defra. http://archive.defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf.

Environment Agency. 2009. The Thames Estuary 2100 Environmental Report Summary. London, UK.

5.3.4. Considerations for evaluating appropriate measures

A systematic and organized evaluation protocol is helpful for articulating how a proposed activity can be evaluated to see if its expected outcomes are particularly effective for the area of concern. It is an essential tool for all decision-making bodies as they require a strategic framework for more systematic and consistent processes in order to promote their mission, particularly for risk assessment and for enhancing the quality of the environment.

Actions	Considerations/ operations	Outputs / benefits
Adaptation of a risk based approach	The likelihood of flooding The potential impact of flooding	Incorporates both existing and potential risk
Determination of a proportionate approach	The cost of appraisal should be appropriate to the level of investment required for the project. Information costs should be balanced against greater accuracy	Output is more effective when there is a balance between cost effectiveness and accuracy
Understanding the problem	Define the flood problem carefully and understand the risk and potential solutions	Problem definition helps in identification of the priorities that needs to be aided first
Working within the hierarchy of decision making	Feasibility Plan National priorities and its position within the plan selection Taking account of legal and ethical issues	Output from such planning is generally well-organized and priority-based. Local communities are benefitted the most when work takes place without changing the existing framework of decision making

Stakeholder cooperation	Engaging all stakeholders and canvassing their views, goals and objectives will lead to an evaluation which represents the interests of all	Encourages community engagement, awareness and overall development
Identifying baseline and multiple solutions	The status quo is a useful comparison and also critical in evaluating the NPV of the proposal	Opens multiple windows for problem- solving, provides time for evaluation of products
Integrating environmental assessment	There may be statutory environmental assessment requirements	Environmental assessment identifies opportunities for enhancing the environment

5.4. Tools for decision makers, including simulation and visualization

Decisions regarding flood risk management are complex and require wide participation from technical specialists and non-specialists alike. There is clearly a role for tools which can predict the outcome of decisions, communicate risk and interface between stakeholders. To that end a large range of tools have been developed to aid the decision making process.

The list is long here: for example, a recent European project (ENCORA n.d.) identified the following tools: Planning Kit, Water Manager, IRMA-Sponge DSS Large Rivers, IVB-DOS, STORM Rhine, MDSF, EUROTAS, Flood Ranger, DESIMA, NaFRA, PAMS, HzG, DSS-Havel, WRBM-DSS, Elbe- DSS, INFORM 2.0/.DSS, RISK/RISC, FLIWAS, FLUMAGIS, DSS ñ RAMFLOOD, ANFAS, MIKE 11 DSS and EFAS. New tools are constantly evolving and it is therefore impossible to discuss all of those currently available in this section; furthermore, it is likely that new and better tools will replace them. The aim of this section is to introduce the various types of tool that have been developed in relation to the different aspects of urban flood risk management; no endorsement or recommendation for particular systems is intended.

These tools are sometimes collectively referred to as Decision Support Tools (DST). Flood risk management tools are often quite intricate, due to the complexity of hydrological systems, and the effects that flooding has on so many different aspects of society and the environment. The purpose of these tools is to aid decision makers with information and analysis, education and communication, and ultimately decision making and application. By using visualization, these tools widen the possibilities for participation. A good tool or series of tools can be invaluable in simplifying the assessment, communication and decision making process, and can be particularly useful for the Multi-Criteria Assessment discussed earlier in Section 5.2.

Table 5.4 identifies a range of tools and techniques and indicates their relevant purpose. The following section gives some examples of these tools and their practical application; and finally how these can be combined to form a complete Decision Support System (DSS) is described.

Table 5.4: Decision Support Tools

Tool or technique	Purpose	Description
Geographical Information System (GIS)	Inform, analyze and communicate	Computer aided, geospatial mapping information analysis and presentation tool
2D/3D flood modeling	Inform	Identify flood hazard (extent, depth, velocity, time of onset) for various return periods over time
Evacuation and loss of life models; Evacuation process modeling; Life Safety Models (LSM)	Inform and analyze	2D/3D modeling combined with other parameters such as demographics
Breach Analysis	Inform and analyze	2D/3D modeling combined with time
Simulation games	Educate and communicate and training	2D and 3D computer visualization tools to explain flood risk and various solutions
Planning exercises, games and toolkits	Educate, communicate, train and decide	Physical and computer based tools to agree consensus on solutions, based on set criteria (such as planning regulations)
Checklists	Decide	To assess flood risk development proposals for completeness against industry guidance.
Decision Support Systems	Inform, Educate and Decide	Compilation of tools often linking flood risk modeling issues with socio-economic and other issues.

5.4.1. Geographical Information System (GIS)

A Geographical Information System (GIS) is a computer-aided mapping tool for recording, collating, analyzing and displaying spatial information. The format is readily accessible with the information being linked to a known geographical reference point. GIS permits the user to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, reports, and charts. A GIS helps the user to answer questions and solve problems by looking at the data in a way that is quickly understood and easily shared.

GIS layer combines spatial information with additional database information to provide a query-based data resource. Each object, such as a polygon or line on a plan, can be assigned information about what it is, what area it occupies and other distinguishing facts. A polygon indicating a building, may also state the area, the height of the building, and the construction.

GIS is applicable to all forms of spatial mapping and analysis: archaeological information, census data, flood zones, flora and fauna sightings, land designations, land values, shopping catchment areas and overall urban planning data. It is particularly useful for government and municipalities to enable a wide range of information to be collated, overlaid and thus reviewed simultaneously.

GIS enables flood hazard information, in particular, to be overlaid with other information, such as urban development plans, demographic plans and land value plans. This allows the user to identify the receptors that will be affected by flooding, the vulnerability of those affected, and the value of land and infrastructure affected. This, in turn, can be used to identify the cost impact amongst other issues. Figure 5.7 shows two maps produced using GIS information, one portraying the land ownership and usage type, the other the expected flood depth during a 0.5 percent probability flood.

Figure 5.7: GIS layers indicating land ownership/use (left) and flood depths (right), Source: Baca Architects, Information provided by Environment Agency, West Sussex County Council and Stakeholders.

The above examples are two of a series of GIS layers that have been overlaid to show the main constraints to a potential development site on the edge of a town. This was then used to inform the designs for an integrated urban plan that identified the extent and type of development that could take place over the next 20 years and simultaneously reduce flood risk, contamination and provide environmental enhancements.

Once the information is assembled, GIS software allows the information to be presented and also queries to be carried out from simple information requests through to complex queries, such as identifying the total value of all property within a predicted flood area. More advanced assessment 'plug-ins' can be used to carry out other assessments, such as topographical land changes, or can then be integrated with flood modeling tools to produce new projected flood maps.

5.4.2. 1D, 2D, and 3D flood flows modeling

Computer flood risk modeling can be used to assess the impacts of the various flood hazards described in Chapter 1. Modeling can also be used to test the effectiveness of different flood risk solutions in lesser or greater detail, depending on the development stage within a project.

Any of the types of modeling can be a powerful tool in aiding decision makers to understand flood hazard. However, modeling is only a tool, and can only be as good as the information put into it. Once produced, model outputs must be calibrated against historic flood records and eye witness accounts.

Two-dimensional (2D) modeling or linked 1D/2D modeling is developing as the industry standard for assessing flood risk and flood hazard in various parts of the world. This combines hydrological modeling with GIS information, such as two dimensional land levels, surface roughness (such as the difference between hard landscaping and fields or woodland) and buildings or other obstacles. This type of modeling can also introduce timing information (adding the third dimension), to see how a flood will progress through a site, thereby identifying which areas will be affected first and for how long they will be flooded. It can also be used to assess the impact if a flood defense should be breached. Once a 2D model is produced it can be used to test out various solutions and development proposals. Figure 5.8 shows still photographs taken from an animation of an extreme flood on a proposed new development at two different stages. This type of information can be very helpful for identifying safe routes and planning evacuation procedures.

Figure 5.8: Extracted images from an animation of a 1 in 1000 year flood on a new development plan in Norwich, UK. Source: JBA Consulting and Baca Architects

Breach Analysis is another form of 2D/3D modeling used to explore the potential effects of flooding should a flood defense or dam be breached.

Outputs from computer modeling are typically produced in a GIS compatible format so that they can be integrated with other GIS information and used to produce flood extent mapping, flood hazard mapping and flood zoning information.

5.4.3. Evacuation and loss of life models and evacuation process modeling

Evacuation and Loss of Life Models, or Life Safety Models, are specific types of 2D/3D modeling, which combine 2D modeling with demographic information. This allows identification of the vulnerability and awareness of receptors. This can be used in order to determine the potential loss of life and to assess evacuation times available, potentially aiding with phased evacuation.

Box 5.4: Life Safety Model (LSM)

The Life Safety Model (LSM) developed by HR Wallingford (n.d.) shows the impact of flooding with or without a flood warning. The LSM includes many features such as:

a. The flood wave evolves with time. This evolution has different effects upon people that i. get warned; ii. start evacuating; iii. reach safety; iv. get stuck in traffic or floating cars; and v. are killed.

b. The time-varying flood condition (depth and velocity) encountered by people affects their resilience, survival capacity and their speed. There are people drowning because they are swept away by the flood, but also as a result of exhaustion due to continuous exposure.

c. If people evacuate by car, engines can stop or the car can get swept away.

d. The buildings can collapse after being hit by the flood wave or as consequence of a continuous exposure to the flood.

e. People can be modeled as individuals, or as groups that do not separate during an evacuation. The slowest members would slow down the group and the fastest members would enhance the speed of the slowest.

f. People in the model can receive different types of warning.

g. People can evacuate along roads or along footpaths, toward a set of safe havens predetermined by the user. Vehicular movement is modeled by a traffic algorithm that can represent reduced speeds due to congestion and bottlenecks.

Source: FLOODsite. n.d. (a) and (b); HR Wallingford. n.d.

Evacuation modeling for flood risk events tends to be 2D/3D GIS based, due to the extent of the area that may be affected by flooding. This form of evacuation modeling uses a dynamic traffic model, such as INDY, to determine the time required to evacuate a risk area (FLOODsite n.d. (d)). This can also be combined with flood risk modeling, such as breach analysis, to determine the critical areas requiring evacuation in order to optimize the evacuation system.

Evacuation modeling for fire and earthquakes can be 4D, incorporating all three spatial dimensions and time; it may also be used in combination with agent-based artificial intelligence to include behavioral modeling. More detailed building scale modeling may be used in the future to inform the movement rates and patterns used in city scale evacuation planning, particularly for hurricane or tsunami events.

5.4.4. Simulation Games

Various organizations have produced simulation games, some of which are available online. These are designed to improve awareness of flood risk in an enjoyable manner; for example, 'Stop Disasters', produced by the UNISDR (n.d.) invites users to spend a given budget on development enhancements to reduce the impact of one of five different disasters (flood, hurricane, earthquake, wild fire, and tsunami) around the world. In the case of the flood and tsunami disasters, the short game introduces some of the solutions that need to be considered to reduce flood risk, such as building location, emergency planning and structural and non-structural solutions. The game provides information about the cost and susceptibility of development options, as well as the cost and effectiveness of flood risk 'defenses'.

The FloodRanger game (Discovery Software Ltd. n.d.) was developed with UK Government funding, as part of the UK Foresight initiative (Evans et al. 2004); It enables users to try several different flood solutions (mostly structural) to manage the flood risk to an area in the UK over a 100 year period and simultaneously to provide housing and employment. The game is designed to work with two climate change scenarios derived from the Foresight project and presents 3D visualization. A second version, named 'FloodRanger World' also exists; this allows the user to create a FloodRanger game for non-UK locations.

Levee Patroller (Triadic Game Design n.d.) is a game specifically aimed at improving the awareness of the general public in identifying signs of damage to dykes in the Netherlands. It uses gaming technology developed and provides an immersive visualization from the first person perspective. Currently, the game is integrated into a course offered by Deltares (n.d.) to teach levee inspection; it is also implemented and internally used by six Dutch Water Boards, and is permanently exhibited at the Nemo Science Museum in Amsterdam.

Simulation games can be complicated and costly to produce; they are rarely used as decision-making tools. They are more likely to be produced based on the information produced from other decision-making tools to aid communication or for training purposes.

5.4.5. Planning games and toolkits

Planning and consultation games, such as Planning for Real (n.d.) can be very useful tools for bringing together planners with flood risk engineers to identify mutually acceptable criteria. These games are relevant due to their ability to raise awareness of flood risk and the acceptance of flood risk management solutions in the context of urban growth and development. This form of consultation is focused on place making and community: it does not place a high priority on flood risk management. However, when combined with other assessment tools and planning toolkits, it can improve understanding and can lead to more sophisticated and broadly acceptable solutions, particularly where non-structural flood solutions are being considered. Figure 5.9 shows one such program being used in community consultation to test an integrated planning toolkit with 2D flood hazard mapping to determine the optimum and safe site layout.

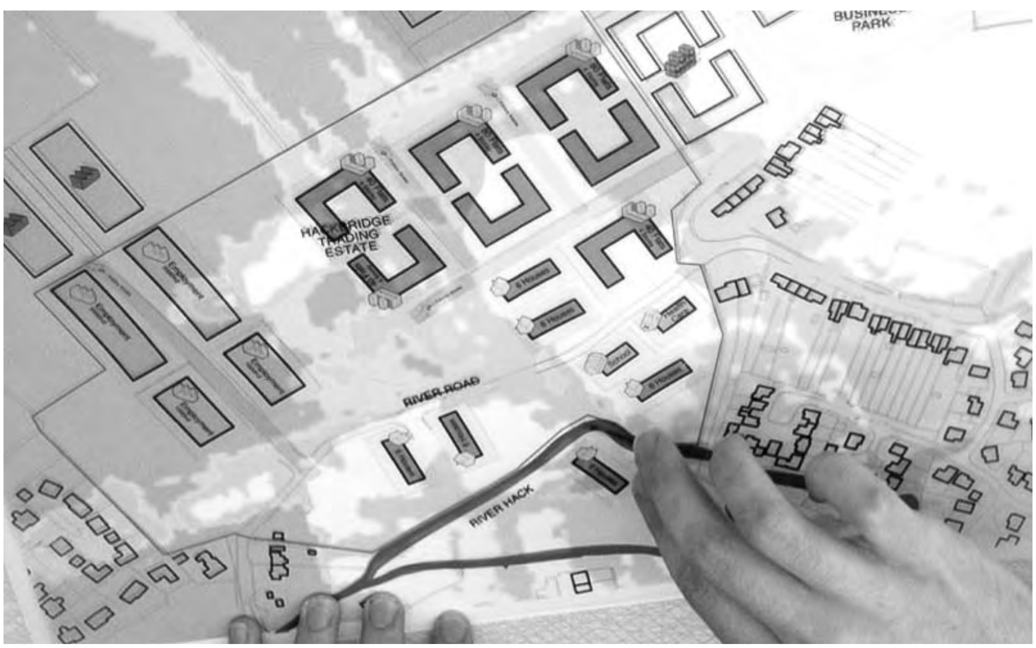

Figure 5.9: Planning for LifE in Hackbridge, U.K. Source: Baca Architects

Physical planning exercises and games can be more effective than computer simulations in engaging with multiple stakeholders, particularly those who may not be computer literate.

5.4.6. Flood simulation exercises

The purpose of simulation exercises is primarily to increase preparedness. They achieve this in a multi-faceted way by normalizing response actions; engendering awareness; testing emergency plans; training personnel; and monitoring preparedness, among other benefits. Simulation exercises can range from strategic desktop paper based exercises to full-scale mobilization of at risk populations.

It is important to carry out simulations of relatively likely scenarios, as well as those for the prospective catastrophic failure of structural measures. Desk simulations can identify the potential cases of secondary impacts such as occurred in the 2011 Japanese Tsunami. They can also highlight possible flaws in emergency plans such as where planned evacuation centers may also be inundated in major events or might suffer a loss of power. Real evacuation exercises, in particular, can raise awareness in the wider population.

Many aid agencies cite Mozambique as a role model for other developing countries for its disaster preparedness strategy. Jorge Uamusse, the Head of the Mozambique Red Cross Society's disaster management, said: "The government invests a lot in disaster preparedness. It holds at least two flood simulation exercises for vulnerable communities living along the rivers, without fail, every year."

The success of simulations can be enhanced with the use of sophisticated computer visualizations of full-scale emergency service responses. Actual exercises may be seen as expensive and disruptive. While this may be the case, it is also possible to use low technology paper-based exercises and small-scale training exercises to achieve many of the same objectives. It is important to be clear about the objectives of any exercise as the range of stakeholders will vary depending on the level of sophistication of emergency planning and the cost benefit of large versus small-scale operations.

5.4.6.1. Choosing an appropriate exercise

The appropriate type of exercise may be determined partly by the objectives but also by the maturity of emergency planning existing in the system. Emergency planning maturity and possible suitable simulation exercises can be summarized as shown in Table 5.5.

Table 5.5: Possible simulation exercises

Some awareness of flood risk but no clear idea of roles, responsibilities	Workshop with a wide range of stakeholders to explore and establish roles and responsibilities (for example the UK based dry run exercise which involves communities putting together their own flood plans).
Good understanding of flood risk within government and agencies with clear roles and responsibilities but gaps in emergency plans	Desk-based virtual simulation exercise to formalize operational plans, identify synergies and improve practice.
Detailed and well-formulated emergency strategy but low awareness and preparedness among population and business	Small scale but well-publicized real life emergency scenario. Tajikistan, for example, is prone to flooding. Oxfam held simulations to gather communities together in safe havens, registering and caring for inhabitants before removing them to safer locations elsewhere. The simulations were recorded and web broadcasts are available. Workshops with key stakeholders.
Well-formulated emergency plans with reasonable level of awareness and preparedness among population	Large scale emergency testing. In the Czech Republic a three-day scenario, Vltava Labe 2007, tested the responses of the capital, Prague, and 135 towns and villages. Over the three days different aspects of the response, strategic, political and evacuation was brought under the spotlight. Training exercises In Chibuto in Mozambique, a mobile emergency operations center, government departments, humanitarian agencies, shelter and evacuation planning were tested. The exercise was based on the Government Contingency plan for 2010-11 and for the first time, international partners, including UNDP and some other UN agencies, were involved as participants, and not just observers, as has been the case in previous years. As is usual with this type of exercise, areas for improvement were identified, which will help to strengthen response mechanisms.

5.4.6.2. Evacuation timings

The time taken to evacuate populations can be inferred from known transport parameters and analysis of past emergencies. However, real time large scale flood simulation exercises can reinforce and inform the planning of evacuations: an example of this occurred in the Belize flood simulation, coordinated by the National Emergency Management Organization and the Belize Electric Company Ltd. Potentially catastrophic dam breaks in San Ignacio and St Elena will require early warning and evacuation procedures to save lives.

The flood simulation had as its objectives to test and inform the public about the existing warning system; establish if the initial warning time estimated by the model will give people sufficient time to reach designated safe areas; test the evacuation routes and safe area system; analyze how people, local economies and government would be affected by the flooding; and to record the information to update all plans required to save lives, making this publicly available following the exercise.

5.4.6.3. International cooperation

International cooperation in managing disasters is often necessary as many events cross boundaries; others, although contained within national borders, require the assistance of emergency responders internationally. An example of a regional simulation exercise is the ASEAN Regional Disaster Emergency Response Simulation Exercise ARDEX06 which has the objective of testing and enhancing the capacities and capabilities of member countries.

5.4.6.4. Community awareness

Raising awareness and training of communities can be the aims of simulation exercises. In Vietnam, for example, preparation for the monsoon season, funded by external donors, involves simulation and training rolled into one. Communities learn how to reinforce their homes to better withstand strong winds, to draw up emergency evacuation plans and to practice responding to early warning signs designed to alert fishing boats at sea. First aid training was also offered to communities. The simulation was supervised by the commune's army steering committee and the steering committee for flood and storm control.

"This simulation is a good chance to raise local awareness of flood prevention and to manage storm damage in our areas. It is especially important for us right now with the incoming storm season," said Chairman of the commune's People's Committee, Nguyen Huu Quoc.

Lasting from 1 March 2007 until 30 April 2008, the Community-Based Disaster Risk Management (CBDRM) project aimed to improve disaster preparedness and management by communities and authorities in Vietnam. Some 21,000 impoverished people in central Vietnam have been engaged in various forms of disaster preparedness activities.

5.4.6.5. Communication and learning

Simulations allow for streamlining and optimization of processes. Individuals and organizations may learn how to better manage their own actions and operations. Similarly, the communication between organizations and individuals may be improved. Face to face encounters of responders and officials from adjacent organizations leads to knowledge sharing and increased confidence in emergency plans. The Safer Cities case study of Dagupan City in the Philippines illustrates the significance of setting up an operational early warning system and evacuation plan, as a mechanism to draw people together in pursuit of collective action towards building safe and resilient communities (Iglesias 2007). The approach called for identifying viable preparedness and mitigation measures, CBDRM and good governance. Lessons learned included:

- Early warning systems are more effective if individuals and groups understand the benefits of such systems
- Community involvement in EWS development leads to systems that respond more quickly
- Drills can test plans and show strengths and weaknesses
- The simulation exercise helped each sector involved to share their knowledge and skills in preparedness and response, through allowing others to witness, impart comments, and eventually replicate this kind of endeavor.

5.4.7. Decision Support Systems

Though the above tools can be used independently to inform specific decisions, they can also be combined into a structured Decision Support System (DSS). The aim of a DSS is to provide a comprehensive system to aid communication with other stakeholders and to assist with individual or group decision-making. Typically components of a DSS are:

- A Database Management System (DBMS), which is used to collect and organize data.
- Knowledge or knowledge-base management systems (KBMS). This is the filtered or interpreted result of information from the data and relevant context as opposed to the raw data itself.
- Models of factors such as flooding, urban growth, socio-economic, and climate change form the model base management system (MBMS).
- A Graphical User Interface (GUI), which is typically GIS-based or browser-based.

A DSS can be designed to incorporate a series of scenarios and variables such as growth or climate change, and be used to quickly rule out or prioritize solutions. It is important in identifying solutions that the variables incorporated are clearly expressed in the results, to enable decision makers to make informed choices. As the FLOODsite project argues, "Decision uncertainty can be expressed as the rational doubt as to what choice to make and it is important that all DSSs provide the decision maker with information on uncertainty, allowing the user the choice of either accepting the uncertainty (as the decision they are making is robust to that uncertainty) or exploring ways of reducing doubt."

Case Study 5.4 examines the application of this principle in Ho Chi Minh City, Vietnam, with the aim of identifying the most appropriate flood management strategy under large hydrological, land subsidence and urbanization uncertainties.

Previous figures have illustrated some of the modeling and visualization components that might be included in a DSS. One such application is the European River Flood Occurrence & Total Risk Assessment System (EUROTAS), which uses ArcView GIS software. This system allows queries to be constructed, based on specific goals and conditions for a given scenario, to identify which simulation satisfies the goals (after FLOODsite 2007).

The specific aim of a DSS, as with any tool, needs to be considered from the outset and is often best designed in collaboration with the intended users to ensure that it is appropriate to the defined objectives.

Case Study 5.4: Integrated Flood Management Strategy for Ho Chi Minh City (HCMC), Vietnam

Some 60 percent of Ho Chi Minh City (HCMC) is comprised of lowland areas subject to tidal effects. Examining flooding in HCMC is complicated as it is affected by upstream, downstream and local impacts.

Despite an increase in heavy rainfall events, an upgrade to the drainage system in the central districts of Ho Chi Minh City has reduced flood risk. Nevertheless, urban growth in the periphery of the city had as a result newly- urbanized districts arising in sites at flood risk.

To protect the city from sea level rise, a dike and tide gate system is planned. The total cost for the construction of 12 large gates and 170 kilometers of dike could reach US$ 2 billion. The Tide Control Project uses large polders but, although approved, it remains controversial as saline intrusion has been more serious than was initially expected. The construction of a sea dike is also being considered.

Hard engineering or structural measures to minimize flood risk might be unsustainable under large hydrological, land subsidence and urbanization uncertainties. The Steering Center for Urban Flood Control in HCMC points out that an integrated flood management strategy (IFMS) is most likely to be successful in reducing flood risk. Components of an IFMS include:

- Protection to an appropriate return frequency, determined by predictions using historical data and non-stationary analysis
- Adaptation to cope with extreme events that surpasses design criteria
- Retreat, which means restoring space for water to adapt to long-term climate changes.

The dynamic balance among the three components may vary, depending on location and timing. As the Steering Center for Urban Flood Control suggests, it should be decided via a robust Decision Support System (DSS). This case demonstrates that urban flood risk management cannot be associated solely with hard-engineered measures, but rather with an integrated and flexible approach in order to respond to future climate and socio-economic uncertainties.

Source: Phi 2011.

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Food vendors continue to ply their trade in the middle of rising water on the flooded Meenburi Road in the east of Bangkok, Thailand (2011). Source: Gideon Mendel

Chapter 6

Implementing Integrated Flood Risk Management

Chapter 6. Implementing Integrated Flood Risk Management

6.1. Introduction

Chapter Summary

This chapter discusses the process of implementing integrated urban flood risk management strategies which combine structural and non-structural measures. In implementing an integrated approach, the role of well-functioning institutions, the participation of stakeholders, and the engagement of affected communities are vital. Implementation also requires sustainable arrangements for financing. Maintenance of the implemented measures, preventing their failure, and evaluating their utility are also keys to ongoing successful implementation.

The chapter is aimed at answering questions such as:

What is the role of formal and informal institutions in integrated flood risk management? What are the challenges that policy makers and flood experts may need to overcome? Why are stakeholder involvement and community engagement important in integrated flood risk management? Where can cities find the financial resources necessary for implementing flood risk management measures? What issues need to be considered for maintaining flood risk management measures? Why is evaluation necessary, and what process should be followed?

The key messages from this chapter are:

- Integrated urban flood risk management is set within and can fall between the dynamics of decision making at national, regional, municipal and community levels.
- Integrated flood risk management requires coordination between national governments, city governments, public sector companies, including utilities, along with civil society, non-government organizations (NGOs), educational institutions and the private sector.
- Engagement of the community at all stages of risk assessment through implementation to evaluation will contribute to the success of measures and may generate extra knowledge and resources, as will the utilization of measures that are community-designed and implemented.
- The sources of finance for integrated flood risk management are broad and can benefit from a partnership approach which includes contributions from multiple stakeholders as well as international donors.

- Implementing processes for adequate long-term Operations & Maintenance (O & M) is a critical aspect of implementation.
- A program of monitoring ensures that measures have the ability to perform to the required standards and prevents failure, as well as provides learning for the future.

Action to tackle flood risk is clearly warranted but is often delayed or completely neglected. This is despite the fact that there exist known solutions that can effectively reduce risk. When measures are taken it is also sometimes seen that their implementation falls far short of the original strategy, or into disuse.

Promoting an integrated flood risk management approach for rapidly developing urban settlements is a huge challenge. It involves many changes which may run counter to traditional thinking and to the natural desire of inhabitants to build a structural flood defense – and forget about flood risk. Such traditional methods have served reasonably well in the past, saving millions of lives, protecting assets and giving peace of mind. But they will not be comprehensive or flexible enough to adapt to a future of climate change, urbanization, urban development and expansion, all of which, especially in developing nations, puts millions more at risk.

Modern thinking about flood risk involves dynamic decision making which includes relevant institutions, involves stakeholders, and engages affected communities – which are all the more important attributes as emphasis is placed on non-structural measures to manage risk that require wider participation and often require a change in traditional management methods. It will also remain critical to be able to implement appropriate structural measures, and to maintain and adapt those measures already in place. Implementation, moreover, can be difficult to achieve where municipal management suffers from a lack of technical capacity, funding or resources.

The chapter is divided into seven sections. Section 6.2 covers the role of formal and informal institutions and argues for the creation of strong and effective institutions. Section 6.3 discusses the important role of community engagement in flood preparedness and mitigation and Section 6.4 deals with the specific application of community-based measures to enhance resilience. Section 6.5 describes the financing and resourcing measures required to effect change, while Section 6.6 covers the issues to be taken into account when operating and maintaining both structural and non-structural flood risk management measures once they are implemented. Section 6.7 details the monitoring of projects and processes within integrated flood risk management in order to prevent their failure. Finally, Section 6.8 discusses the range of approaches and methods for evaluation of disaster relief, including urban flood risk management measures.

6.2. Effective institutions and stakeholders

Flood risk management is seldom, if ever, the sole responsibility of individuals. Flood risk is best managed through collective efforts and with the understanding that actions in one location could have a counter-effect on that of a neighbor, as Figure 6.1 below illustrates.

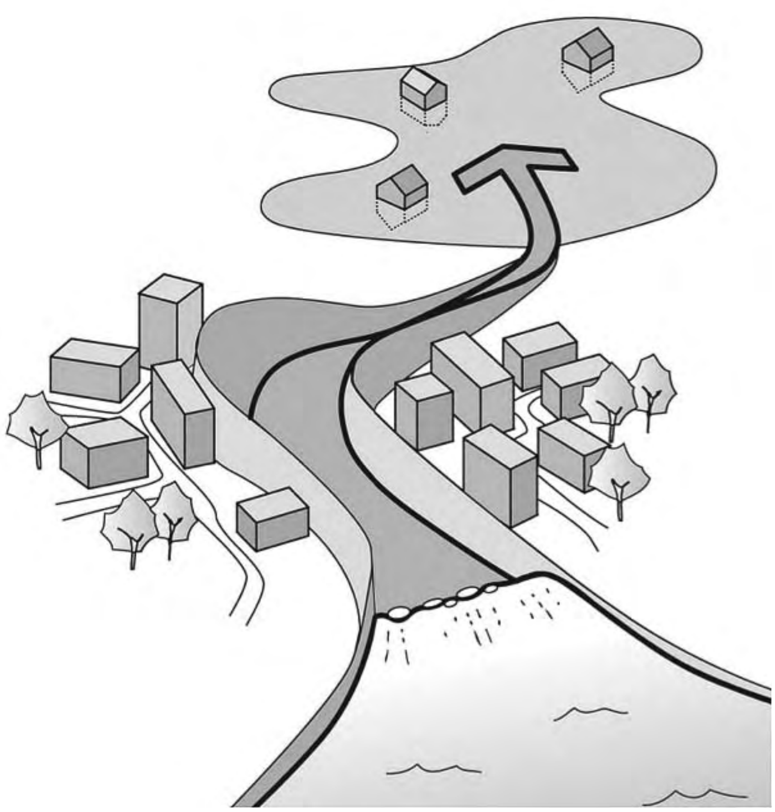

Figure 6.1: Flood defenses in one location could increase risk elsewhere. Source: Baca Architects

Institutions are the set of informal and formal rules that facilitate and constrain human behavior, or define `the rules of the game' (Bromley 1989; Ciriacy-Wantrup 1971; Kiser and Ostrom 1982; North 1990). By its very nature, flood risk management is multi-institutional. A range of institutions have important roles to play, including local, regional and national governments, community groups, utilities, and private businesses – and not forgetting banks and the insurance sector. Developing effective institutions is vital to overcoming the real challenges of managing flood risk, which are illustrated in Box 6.1.

Box 6.1

Challenges for urban flood risk management

Information

- Lack of risk awareness or perception
- Difficulties in responding to the uncertainties of climate risk predictions
- Difficulties in responding to the uncertainties of urban growth and planning and managing informal development.
- Lack of understanding of integrated flood risk management responses

Ownership

- Understanding where responsibility lies
- Taking responsibility and overcoming the "not in my term of office" syndrome, in which difficult decisions and initiatives are deferred to a later political office holder
- Weak municipal capacity and performance
- Lack of engagement of the private sector
- Lack of public engagement and consultation

Resources

- Underfunding or under-resourcing
- Lack of oversight and enforcement of land use regulations
- Lack of supporting infrastructure
- Shortage of skilled personnel
- Inappropriate infrastructure maintenance systems

– Actual cost and perceived cost

Belief

– Fear of lack of effectiveness of measures
– Perceived cost of measures
– Negative perception of the consequences of risk and the benefits of measures
– Lack of faith in government to effect change.

6.2.1. The role of institutions

There are generally considered to be two types of institution, informal and formal.

Formal institutions are those that incorporate written rules or laws, such as governments, religious or faith group organizations, NGOs or other large organizations, such as private corporations; or are those that operate under specific laws, such as banking organizations, and energy and water companies. In flood risk management, formal institutions typically take responsibility for information gathering, communication, policy setting, decision making, defining and enforcing property rights, establishing building codes and planning regulations, financing and implementation.

Informal institutions are those that have been established on the basis of agreed and perhaps unwritten or codified principles, such as community groups. In developing nations, these informal institutions are an integral part of daily life and are relied upon, particularly where formal institutions are highly bureaucratic. Informal institutions are often involved in information gathering, communication, decision making and implementation.

Flood risk management is typically dependent on these two types of institution working together in an ordered fashion over long-term. Establishing which specific institutions are responsible for various elements of flood risk management is critical to implementation, operations and maintenance and ongoing assessment of the measures taken.

Integrated flood risk management often requires greater coordination than is usual between national governments and ministries, city governments, public sector companies, including utilities, meteorological and planning institutions, NGOs, educational institutions and research centers, and the private sector. It is essential to understand the capacities and incentives of these institutional actors, including how they choose or are able to use their own limited resources under high levels of uncertainty. Government decisions about the management of risk are typically balanced against competing, often more pressing, claims on scarce resources as well as other priorities in terms of land use utilization and economic development.

The most appropriate institutional arrangements for managing integrated flood risk management systems need to be identified in any given situation, as well as those for monitoring and regulating the institutions that are responsible for the implementation of the measures undertaken. In Box 6.2 below are a number of factors that need to be considered in order to implement integrated flood risk management across institutions.

Box 6.2: Institutional considerations

- How does the highest political authority show its commitment to flood risk management?
- How adequate are the mechanisms for demonstrating this commitment?
- To what extent are the civil society and the private sector committed to flood risk management?
- Is there a policy that specifies flood risk management and reduction as a priority?
- Is there a process for developing, coordinating and continuously improving policies and strategies for flood risk management?
- Is there separate legislation for flood risk management?
- What participatory approaches do government and NGOs adopt in their risk reduction programs and activities?
- Are there incentive systems that encourage investment in flood risk management?
- Does flood risk management promote individual and community responsibility for protection from flooding and compliance with early warnings?
- What mechanisms exist to coordinate flood risk management and stakeholders at the city level?

Source: Adapted from AfDB et al. 2004

As pointed out by the World Bank, countries with well-performing institutions are better able to prevent disasters (World Bank 2010). Nevertheless, in many countries, there is a lack of both suitable institutional arrangements and suitable policy frameworks to encourage integrated flood risk management. This mismatch between governance of official disaster management mechanisms and what is actually needed for implementing integrated flood risk management is a major barrier to its implementation.

Without technical assistance and other capacity building measures, there is a danger that institutional and policy fragmentation may lead to a failure to address wide-ranging problems in an effective manner. For instance, if a local government's strategy relies on purely structural flood risk mitigation measures, this may create 'false security', which subsequently, may undermine the implementation of an integrated flood risk management approach (Wamsler 2006).

For implementing integrated flood risk management the following success factors therefore need to be considered (AfDB et al. 2004):

- Political commitment to flood risk reduction depends on the ability of decision makers to provide the requisite vision, direction, policy efficiency, material and non-material support.
- Effective implementation of integrated flood risk management depends on the effective utilization of national, regional and local institutional resources, including policy, legislation, structures, financial resources and competencies.
- Rights-based, active and value-enhancing involvement of all stakeholders is a necessary factor for good governance.
- Emphasis on local action while linking the local with the regional, and national is required.
- Consistency by all stakeholders is essential for enhancing the governance of flood risk reduction.

Well-organized institutions are also required to direct flood risk infrastructure operations and maintenance, and to accrue the resources required to fund these. Additionally, it is the role of institutions to ensure that they respond to the whole range of flood sources, from the more frequent to the much rarer extreme events, which are typically, more devastating and more costly to deal with.

Where the roles of different institutions is not well established in flood risk management, they should ideally be developed both to complement each other and existing systems, to create efficiency in the delivery of measures and their faster uptake. Identifying which institutions are most effective in the delivery of these requirements is fundamental to success.

The responsibilities for flood risk management must be clearly allocated. These would normally be held in the first instance by national and regional governments, and implemented through municipal authorities. As such, national and regional politicians must allocate the responsibility to specific organizations; clearly identify and demarcate their responsibilities; provide sufficient funding requisite to flood risk; enforce the ‘ring fencing’ of those funds; and ensure that required works are carried out. In many cases, as discussed above, informal institutions such as community groups may have a particularly important role (for example, where property rights and ownership are not well-documented in formal institutions or where community groups are more effective or trusted in communication).

In order to initiate this process, advantage can be taken of flood events, as these can make politicians aware of the impacts of floods and how these need to be reckoned with – which can emphasize the necessity for a flood risk management strategy.

6.2.2. How to perform institutional mapping

Flood risk management depends on different institutions as well as individuals working together. Identifying which institutions are most effective in the delivery of these measures is fundamental to success. Institutional mapping is a tool that can be used to identify the awareness and perception of these key institutions, both formal and informal, as well as that of key individuals, inside and outside of a community, a city, a province or a country. It will also help to identify the relationships and importance of these different actors to one another or to individuals.

Method

A facilitator and an observer, or note-taker, will be responsible for the activity. It is important to bear in mind that good facilitation skills are crucial. Complementary tools that can also be used during the institutional mapping may include social mapping and Venn diagramming. A step by step process for institutional mapping is outlined below. This incorporates the factors to be considered at each stage. The procedure should be adapted to local contexts and needs. Required materials are markers and flipchart paper.

1. Select local participants

2. Provide introductions and present the purpose of the activity

3. Produce (draw) an institutional map

4. Analyze the institutional map

5. Wrap-up

1. Select local participants

The first step will be the identification of the groups of people to talk to about their perceptions and experiences with regards to flood risk management. The number of participants may vary, but most often consists of five to twelve people. It will not be enough to focus on formal institutions only. Informal institutions should also be included. Different sessions (with different actors, as necessary) can take place if this will lead to a better outcome.

Appropriate selection of participants means that policy makers and flood experts will have the chance to get valuable feedback from the flood-affected population or other relevant formal or informal institutions. Moreover, flood affected communities will have the chance to have a say about flood risk management.

2. Provide introductions and present the purpose of the activity

The facilitator and observer (or note-taker) should begin by introducing themselves as well as all participants, and clearly explain the purpose of the activity. It is important that participants understand and feel comfortable with what will follow.

3. Produce (or draw) an institutional map

The participants should be asked to identify actors with whom they interact or would interact in the process of flood risk management or a flood emergency. Focus however should not be limited to flood emergency as this will limit the identification of the full range of stakeholders that are, in one way or another, responsible for urban flood risk management. These actors could be physically present in the area or could be associated directly or indirectly and could be individuals, groups, or organizations. Informal relationships should be also considered.

Questions to help inform the mapping may include but not be limited to:

- Which institutions are relevant to flood risk management?
- What are their interests, roles, relative power and capacities?
- What are the mandates of those institutions?

- How do they interact one another or with the local population? Are there any conflicts?
- Where are the overlaps with other organizations?
- What are their plans for responding to an emergency?
- What are the strengths and weaknesses of these institutions?

The visual outcome at this stage (i.e., map) will be used as a source of information for the discussion or the analysis that will take place in the next step. More specifically the map will help to better understand the relationships of different formal and informal institutions or individuals and to identify the key factors affecting their relationships with the others, and the implications of these relationships in managing flood risk or a flood emergency.

4. Analyze the institutional map

At this step the relationships shown on the map can be explored. Discussion may be focused on a number of factors such as but not limited to:

- Influence
- Source of funding
- Availability of information
- Social or cultural issues
- Challenges and opportunities
- Threats and weaknesses
- Legal or institutional aspects
- Collaborations and partnerships
- Good practice (sharing of knowledge)

Participants can be asked to explore and explain the ways in which each of these relationships can be changed or improved. Potential changes with regards to flood risk management (e.g., new measures, policy change) in their area should be discussed on the basis that they might impact these relationships in a positive or a negative way.

This stage will identify potential ways for strengthening or improving relationships between key actors and explore possible opportunities and challenges for flood risk management. This will form the basis with which current measures can be improved or new measures can be adopted.

5. Wrap-up

It should be made clear to the participants how the information will be used. Participants can also reflect on the advantages and disadvantages of the process.

Further reading

World Bank. n.d. "Institutional Perception Mapping." Available at:

http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375938992/2_Insti_perception_mapping.pdf

Mukerhjee, N. and van Wijk, C., ed. 2003. Sustainability Planning and Monitoring in community water supply and sanitation – a guide on the Methodology for Participatory Assessment (MPA) for community-driven development programs. Washington, DC: World Bank.

6.2.3. Linking flood risk management with urban governance and management

According to the United Nations Development Program, "Governance is the umbrella under which disaster risk reduction takes place" (UNDP 2010: 1). In well-planned and well-managed cities the impacts of flooding can be mitigated because of the measures that have been implemented to reduce flood risk and flood impacts. Such measures may include provision for drainage systems, flood zoning restrictions and land use management to increase surface water management capacity.

However, typically this is not the case in cities and towns that are not adequately planned and managed. Often areas, particular informal settlements, lack adequate drainage systems and rely on natural drainage channels. It is also common for buildings or infrastructure to be constructed either in locations that actually further increase their exposure to flood risk, or in a way that increases their vulnerability to flooding.

Even when policy makers accept the necessity for implementing an integrated flood risk management approach, a lack of capacity to plan, design, implement, operate and maintain flood risk management systems is likely to be a severe constraint on efforts to ensure its adoption. Box 6.3 outlines the way in which constraints on city governments can be further linked to legal, vertical as well as horizontal government relationships, and organizational aspects.

In order to link flood risk management to local realities, the decentralization of local governance functions must also be taken into account (Christoplos 2008). Decentralization can make city governments more efficient, responsible and responsive. Due to spatial proximity, local authorities are able to make well-informed decisions. Nevertheless, decentralization may not bring the anticipated results if local governments lack the technical capacity and resources to implement measures. Wider supportive political and organizational underpinning is vital to ensure the success of integrated flood risk management as local authorities may suffer from constraints similar to those described belowin the box.

Box 6.3: Constraints on local governments

Legal exclusions

- City boundaries often do not include areas where the urban poor live, thus placing them outside of municipal jurisdiction
- Municipal divisions may geographically and functionally separate responsibilities
- Legal restrictions on working in informal areas, for example, not being able to supply those populations which do not pay property taxes with services
- Vertical relationships
- Lack of supportive financial and planning frameworks
- Unclear and overlapping responsibilities
- Political competition with higher levels of governments

Horizontal relations

- When cities or provinces share the same water resource that is the source of flooding, but do not perceive this issue as a common problem
- Lack of understanding, information sharing and cooperation between relevant departments or institutions at the local, regional and central level of governance

Limits of organization

- Lack of financial resources in order to increase service provision and build infrastructure
- Weak managerial and technical capacities
- Leadership without institutionalized accountability
- Unwillingness to address urgent local problems
- Local governments are often not responsible for many public services including land allocation, housing, water and other public services
- Lack of adequate information on poverty, environmental conditions, service and infrastructure deficiencies

Sources: Devas and Batley 2004; Satterthwaite 2001; Tanner et al. 2009; Corfee-Morlot et al. 2009

6.2.4. Allocation of stakeholder responsibilities for urban flood risk management

The above discussion about the limitations of local government to fully implement flood risk solutions reinforces the conclusion that there will need to be collaboration from many stakeholders.

For flood risk management to be implementable, its operational requirements must be compatible with the knowledge and technical capacity that are available. In practice, even the simplest technologies can fail due to a lack of attention to operational and maintenance requirements. As seen above, flood risk management, as a multi-disciplinary and multi-sectoral effort, falls under the responsibility of diverse institutions. Therefore, flood risk reduction measures need to be comprehensive, locally specific, integrated, and balanced across all involved sectors.

AfDB et al. (2004) suggests that this can be achieved through:

- Institutional collaboration between stakeholders
- Clear assignment of roles, assumption of responsibilities and coordination of activities
- A common vision by all stakeholders
- An adequate institutional framework.

The case study of Cambodia below illustrates how a program of enhancing flood preparedness can incorporate changes to governance structures and building of capacities at appropriate governmental levels.

Case Study 6.1 Flood preparedness and emergency management programs in Cambodia

Prey Veng which is located on the east bank of the Mekong River, and Kandal which borders Prey Veng in the mid-south of the country, both rank among the most flood-prone provinces in Cambodia. For the communities living along the floodplains of the Mekong River, flooding is a common situation. In 2004, to enhance the capacity of the local governments in flood preparedness and mitigation, the Mekong River Commission (MRC) initiated a three-year comprehensive program aimed to formulate and develop provincial and district flood preparedness programs (Figure 6.2).

Despite the fact that Cambodia had a disaster risk management system in place, consisting of the National Committee for Disaster Management (NCDM), the Provincial Committee for Disaster Management (PCDM) and the District Committees for Disaster Management (DCDM), there was no clear allocation of roles and responsibilities. Through institutional analysis, the Flood Preparedness Programs (FPPs) identify the issues that need to be addressed and prioritize flood risk management measures that need to be implemented.

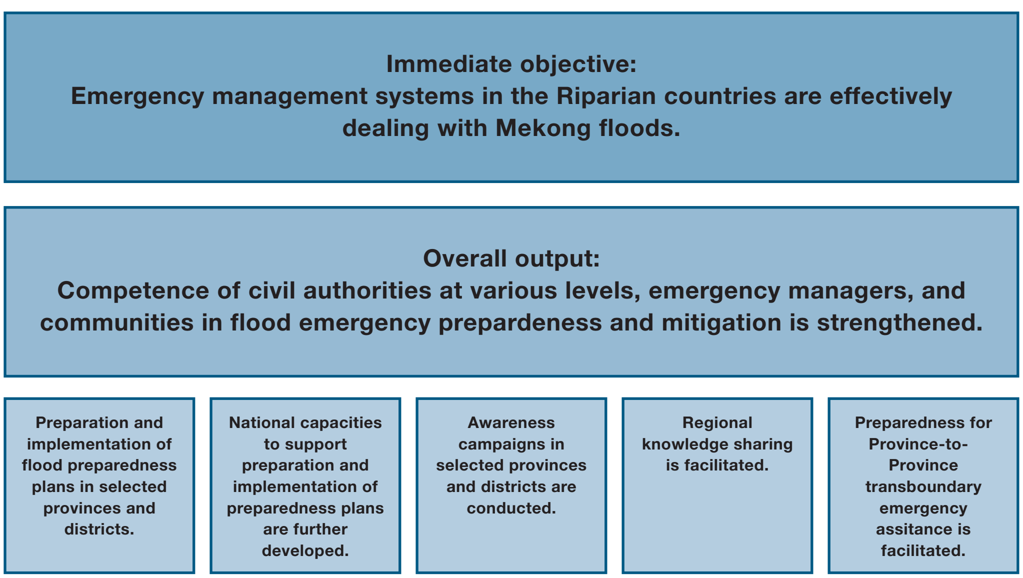

Figure 6.2: Flood preparedness and emergency management program, Source: adapted from MRC and ADPC 2008.

Although integration of flood risk into local development planning processes is not yet completed, significant lessons can be drawn from this initiative:

- Political will at the highest level of government officials and departments is a prerequisite to successfully mainstream flood risk concerns within their sectors and spheres of influence;
- Acknowledgement of the problems, participation and ownership of the local government officials and departments is also necessary to sustain the undertaken activities;
- Identification of local advocates or 'program champions' can increase local stakeholder ownership and facilitate the integration process;
- Decentralization provides an enabling environment for integrating DRR into official development plans;
- Significant efforts should also be given in awareness raising, advocacy and capacity building;
- For effective DRR integration it is vital that institutional capacity for disaster risk reduction is equally provided to all other government departments, such as those dealing with health or gender issues;
- Integration should take place using horizontal and vertical approaches. This means that integration should take place at the level of overall local government development planning processes, and involve departmental or sectoral plans of the various departments;
- Given limited financial resources, integrating DRR into local development plans can be a viable long-term resource allocation option for flood risk reduction.

Source: MRC and ADPC 2008.

Clarity in establishing responsibility for aspects of flood mitigation is crucial. Flood management institutions, which can be the local government or separate administrative bodies, have to face the challenge of managing the whole system properly on behalf of the citizens. When ongoing operation and maintenance tasks are transferred to others, such as private companies, households or communities, it is essential that responsibilities are clearly negotiated, enumerated – and if necessary legislated for. When large river basins are under consideration, the responsibility can cross provincial or even national boundaries and, therefore, greater coordination amongst all relevant stakeholders will be necessary.

Figure 6.3 below shows some of the agencies and legislative acts involved in flood risk management in the UK. These include government departments, 'quangos' (quasi-autonomous, non-governmental organizations), private companies and individual private landowners. The Pitt Review (2008) into the large-scale flooding in 2007 in England, concluded that more clarity was needed regarding the roles and responsibilities of the different organisations responsible for managing flooding from all sources. The subsequent Flood and Water Management Act of 2010 assigned the strategic overview for all sources of flooding and coastal erosion to the Environment Agency (in England) and the responsibility for local flood risk was assigned to Lead Local Flood Authorities. In Wales, the Environment Agency was assigned a Strategic Oversight role for all sources of flooding and coastal erosion and the responsibility for local flood risk was assigned to Lead Local Flood Authorities.

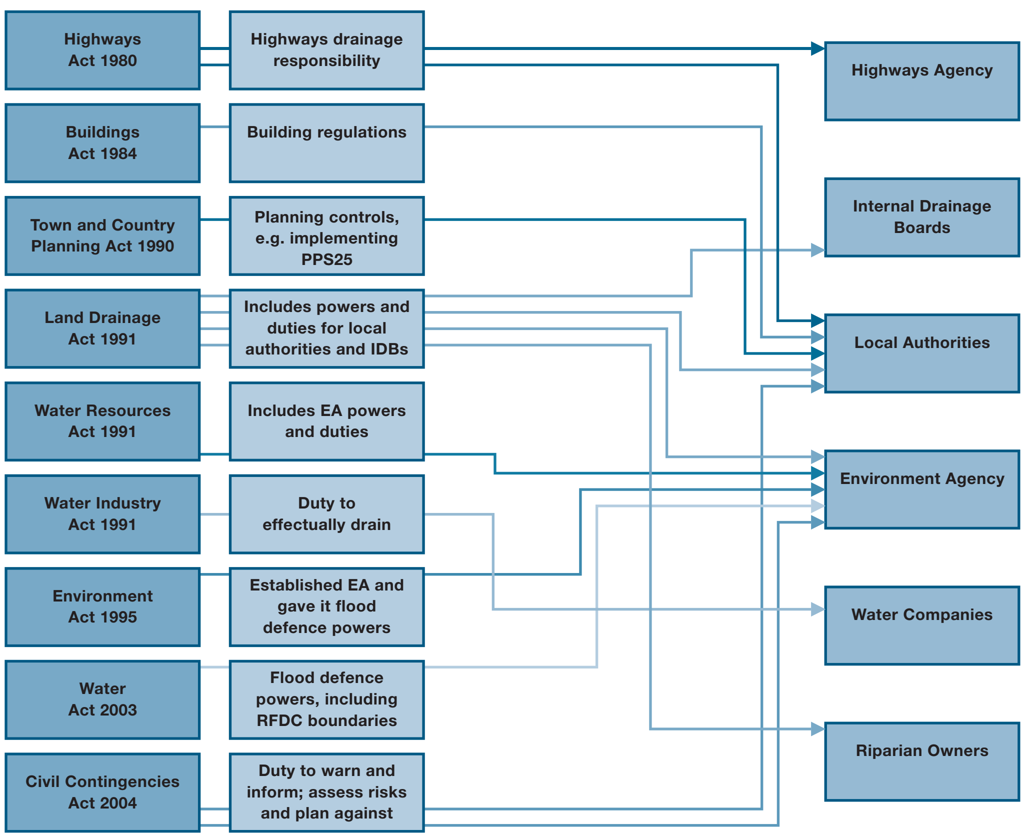

Figure 6.3: Summary of legislation in UK FRM, Source: Adapted from Pitt 2008

Case Study 6.2 below uses the example of the Murray-Darling Basin in Australia to indicate the interplay of institutions and interests in the management of a large-scale catchment area.

Case Study 6.2: Murray-Darling Basin

The Murray-Darling Basin is named for the Murray and the Darling Rivers. It is located in south-eastern Australia, and contains an area of approximately one million square kilometres. The basin area encompasses parts of the states of New South Wales, South Australia, Victoria and Queensland and the whole of the Australian Capital Territory. Major urban and township settlements within the basin include Australia's capital Canberra, Tamworth, Wagga Wagga, Albury, Bendigo, Renmark and Mildura. It supports a population of over two million people and grows more than one third of Australia's food. The basin has a diverse landscape and includes over 77,000 kilometres of rivers, more than 25,000 wetlands, floodplain forests and the Coorong and Lower Lakes that support a wide range of complex and dynamic ecosystems. The basin also contains Ramsar wetlands.

Climate patterns in Australia are characterised by periods of drought and heavy rains. Over time, landscapes, species and ecosystems shift from being flood dependent to flood tolerant. Flooding events in the Murray-Darling Basin enable exchanges and linkages between rivers and flood plain areas to take place, allowing the ecosystem to remain healthy. Flood risk management within the basin is therefore addressed at the broader catchment level and within a water resource and environmental management framework.

Management of the Murray-Daring Basin has occurred over the last 90 years and has always been characterised by inter- and intra-government coordination between the national and state governments and their various department and institutional bodies all of which represent different political, environmental, industry and community interests. Management of the basin has evolved over time and through legislative change. Recent and proposed changes to the management of the basin have caused controversy within various sectors in Australia as institutions compete to ensure their interests are protected.

The Murray-Darling Commission established in 1988 under the Murray-Darling Basin Agreement marked the beginning of a more targeted and integrated approach. The role of the Commission was firstly to manage and equitably distribute water resources; secondly, to protect and improve the environment; and finally to advise the Murray-Darling Ministerial Council. This framework remained largely unchanged until the enactment of the 2007 Water Act. The introduction of the Act can be seen as a direct response to the prolonged drought that Australia was experiencing at the time. Through its enactment the Australian Government recognised the need for legislative and policy instruments to respond to challenges due to climate change, climate variability and reduced water availability. In 2008 this act was amended to transfer power from the Murray-Darling Basin Commission to a newly-established Murray-Darling Basin Authority (MDBA).

The MDBA is an independent, expert-based authority whose principal aim is to manage the Basin's water resources in the national interest. The establishment of the MDBA is the first time a single agency is responsible for the planning and management of the Murray-Darling Basin water resources. Participation from the State Governments in this structure is via the Ministerial Council and the Basin Officials Committee. Representation on the Council is by one Minister from each state government and chaired by the Commonwealth minister. Representation on the committee is by senior government/departmental officials of each state. Both bodies have advisory roles with the Committee also being responsible for implementing policy and decisions of the Council. Local government and community representation occurs at the operational and implementation level through advisory groups that report back via the Committee.

Management of the basin and water allocation has long been a contentious issue within Australia. There was a widely held view that changes to the way the basin is managed were required. Competition between sectors, urbanisation pressures and changes to the economic bases of urban centres continue to provide the political backdrop to management of the basin. These circumstances coupled with prolonged drought followed by severe flooding in parts of Australia, including within the basin, have extended and sharpened the debate around what is the best long-term management solution. The 2010 floods in the state of Victoria caused significant economic damage but were a welcome event for communities further down the system in South Australia as the flood waters enabled the natural flushing process of the Murray River mouth, something which had not occurred naturally for over 10 years. However, in contrast, the 2010/2011 flood events in the state of Queensland, affecting over 200,000 people and providing substantial flows of water into the system, have caused some people to challenge the need for the reform measures proposed (detailed below) within the basin.

Through the 2007 Water Act and subsequent amendments, a legally enforceable national basin management plan has been drafted. The Draft Basin Plan prepared and currently being consulted on seeks to establish a long-term management framework for the Basin. The draft plan seeks to redress the imbalance in water flows throughout the whole system and improve the environmental condition of the Basin area. A central tenet of the plan is a reduction in consumptive water use and reinstatement of environmental flows within the system. The MDBA's fact sheet 'flooding and the Basin Plan' outlines four key messages:

- Periodic flooding is a natural process of critical importance to the environmental health of the Murray-Darling Basin
- The Basin Plan will restore more natural flows to the river.
- State environmental watering and management plans associated with the Basin Plan will be required to detail plans, policies and operating procedures to manage and mitigate unacceptable flood risk
- MDBA is undertaking technical assessments to identify physical or policy barriers that limit effective delivery of environmental water.

The MDBA acknowledges that the Basin Plan will have no effect in circumstance where periods of very high and prolonged rainfall (relatively infrequent) produce large flows that cannot be contained by the regulatory structures (such as dams) on some rivers. Rather, through the reinstatement of environmental flows (Environmental Watering Plan (EWP) linked to the Basin Plan) it is planned to undertake a catchment level water resource and environmental management approach. As part of this integrated and holistic approach, the MDBA requires state water resource plans developed under EWP to be accredited by MDBA and detail the environmental delivery mechanisms and flood-control mitigation measures. The proposed environmental watering as part of the Basin Plan anticipates that through 'piggy-backing' on existing, naturally-occurring small flood events within the Basin that implementation of environmental watering can occur, albeit differently across the Basin. This integrated approach consistent with the catchment level, water resource and environmental management philosophy that underpins the MDBA and the proposed Basin Plan.

The proposed management plan is not without its significant challenges. In attempting to redress the water flow imbalance and implement environmental watering, a buy-back scheme of water allocation rights by the Commonwealth Government is proposed. The allocation of water within the Basin has been a long standing issue of contention with large political implications. Competition between those in the upper catchment area of the basin and those in the lower more arid areas (all in different states and local authorities) is a cause of much debate. Historic agreements to guarantee fixed annual volumes for the most downstream state by the upper states is at the trade-off that the upper states can share equally what remains from the Murray itself, plus can use all the water they wish from their own tributaries of the Murray River, with the exception of declared drought years. These negotiations and agreements sit within a wider political context of differences between primary producing or largely agricultural areas and those of townships or cities. The township and cities debate is divided further politically between those areas that support and/or are supported by agriculture and those which have a more diversified economy.

The proposed reforms attempt to entrench a 'national' approach to managing the basin. However, the proposed reforms continue to fuel intense political debate as the government institutions responsible for implementation and the numerous industry and community groups it affects, continue to have differing and competing interests.

Sources: Murray-Darling Basin Authority website; World Bank, 2006, Integrated River Basin Management: From Concepts to Good Practice

6.2.5. Public-private cooperation

Inclusion of the private sector in flood risk management may involve the utilization of the financial and human resources of business enterprises, or to working with the insurance sector to mitigate the effects of flood disasters. For the private sector to get involved, governments must first put in place the appropriate policy, institutional and infrastructural frameworks. Often the outcomes of mitigation or prevention measures undertaken by private interests depend on what government does (or fails to do) to incentivize them to participate. Resources from both government and the private sector can be combined to form an effective management system.

The role of the private sector in the implementation and delivery of urban infrastructure has been increasingly recognized. Public-private cooperation is often a fundamental component of the strategies adopted by international development organizations and governments, particularly when it comes to infrastructural investments (Tanner et al. 2009).

In flood risk reduction, public-private partnerships can provide to the private sector a better understanding of their interdependence with locally critical infrastructure, and improve coordination with the local stakeholders before, during, and after a disaster (NRC 2011). This was put into practice in Metro Manila as Case Study 6.3 below illustrates.

Case Study 6.3: Multi-stakeholder collaboration for better Flood Risk Management in Metro Manila, the Philippines

Metro Manila consists of 17 cities and municipalities, including the City of Manila, and has a population of over 14 million people. It is a low-lying area intersected by the Pasig River and its tributaries. Severe flooding caused by Typhoons "Ondoy" and "Pepeng" in 2009 has raised public awareness of the underlying causes of flooding. In September 2010, the Mayors of all Metropolitan Manila cities signed a covenant known as the "Estero Declaration", affirming their commitment to protect Metro Manila's waterways, control environmental pollution and prevent the recurrence of flooding.

The Metro Manila Mayors pledged to implement their own anti-littering ordinances as well as clean and dredge the esteros, creeks and other waterways located within their jurisdiction. They also expressed their support to the campaign to dismantle and remove all structures, constructions, and other encroachments along waterways and help relocate informal settlements in coordination with the national government agencies.

On a similar note, the Cities of Pasig, Marikina, Antipolo and the Municipalities of Cainta, San Mateo and Rodriguez signed a Memorandum of Understanding in 2010 on the "Formation of the Marikina Watershed Environs Integrated Resource Development Alliance" also known as the Alliance of Six. The Alliance aims to restore, protect and preserve the Marikina watershed and its environs. The Metropolitan Manila Development Authority (MMDA) supported this initiative by mobilizing various stakeholders such as civic and business organizations, faith-based organizations, non-government and community organizations, within the Marikina watershed to take action on issues such as disaster preparedness and disaster risk reduction.

As part of the Alliance's efforts to involve the private sector in its various activities, a Memorandum of Agreement was put in place with a private firm, which pledged financial support in the cleaning of the local drainage systems. Moreover, two construction companies made available heavy equipment for dredging waterways, esteros and canals – either free of charge, or under a "Borrow Now, Pay Later Scheme".

The case demonstrates that implementing integrated flood risk management requires the involvement of the full range of stakeholders, including regional and local government officials, and the private sector. It is important that these actors show they are committed to address existing and future problems.

Source: Personal communication with MMDA

6.3. Community engagement

Engaging the community in flood preparedness and mitigation is crucial to the success of many measures such as warning and evacuation, and can reduce the cost of other measures such as constructing local defenses or contributing to maintenance of drainage systems. Therefore, community engagement is important for both structural and non-structural measures. Engaging the community throughout the project cycle of flood risk management (assessment, design, implementation, monitoring and evaluation) is also a prerequisite to ensure that the undertaken measures are equitable and effective, and meet the needs and priorities of the entire affected population (Sphere Project 2004; WMO 2008).

Engaging the community in flood risk management is about involving them in measures that may be carried out by such institutions as government, non-government actors, or the private sector. Flood mitigation solutions, both structural and non-structural, thus seek to benefit from community views or participation. Community-based measures, which are covered in the next section, are related but distinct, as they are driven by the community itself: the community designs and implements the measures. Such community-based measures, take their impetus and direction from the experience, capacity and capabilities of the community.

An example of community engagement is seen in Jakarta in Case Study 6.4 below, where the engagement of the community strengthened flood risk management activities and led to the development of greater local capacity to cope with flooding.

Case Study 6.4: Communities engaged in flood risk management in Jakarta

Jakarta is a megacity with complex urban development challenges. After the 2002 flood disaster affected 24 percent of its total land area, UNESCO,, together with local government institutions, non-government organizations (NGOs) and the Indonesian Red Cross, implemented activities to strengthen the flood resilience of communities living in the city sub-district of Bidara Cina.

Bidara Cina has a population of approximately 43,000 and is located in the eastern part of Jakarta along the Ciliwung River, which is one of the major drainage systems in Jakarta. Waste disposal, water supply, health and public hygiene are amongst the main problems that Bidara Cina faces, all of which exacerbate the impacts of floods. During flooding, which usually occurs once or twice a year, many residents have to evacuate to safe places.

Non-structural flood mitigation and preparedness measures were implemented to raise the community's understanding and awareness on the physical and social implications of floods, and to strengthen people's capacity to cope with floods. To ensure the success of the initiative, and maintain the continuity of the project, local organizations were actively involved in all processes, and carried out the various project activities, which included:

- Water quality, supply and user assessment study in collaboration of the Laboratory for Industrial Hygiene and Toxicology – Institute of Technology in Bandung, Jakarta;
- Vulnerability and capacity assessment using Participatory Rural Appraisal (PRA) methods, focus group discussions and questionnaires;
- Public education and training;
- Capacity building for community organizations;
- Publication of a practical handbook for community participation in flood management informed by the outcomes gained from the community.

The establishment of a local community organization for flood preparedness and mitigation provided training and capacity building for existing local organizations. These local organizations then contributed to the dissemination of flood-related information to other communities, and have been actively involved in disaster preparedness activities undertaken by other community organizations in these communities and the government.

This case demonstrates that local community organizations can and should be actively participate in flood preparedness and mitigation, as the success of flood risk management measures considerably depends on the involvement of the full range of stakeholders.

Sources: UNESCO 2007; UNESCO 2004

Each community is unique. Community engagement thus has to take into consideration such issues as their size, income, homogeneity, history of cooperation, and political participation. It is vital that community based organizations (CBOs), community leaders and NGOs that work at the community level are actively involved (Moga 2002). The Sphere Project (2004) recommends that community engagement should, as a minimum, ensure that:

- Women and men of all ages, including the most vulnerable and marginalized groups that live in areas exposed to floods, receive information about the measures undertaken, and at the same time, are given the opportunity to comment and provide their inputs throughout the project cycle.
- The objectives of the measures reflect the real needs, priorities, concerns and values of at risk communities, and particularly those belonging to vulnerable groups, and contribute to their protection.
- Measures are designed in a way that maximizes the use of local skills and capacities.

6.3.1. Why is community involvement important?

The success of flood preparedness and mitigation measures depends considerably on the involvement of local communities. Engaging the communities can further increase the effectiveness of the undertaken measures, and can also add an element of sustainability on their outcomes.

Flood risk management measures have typically been driven by top-down decision making, without the active involvement and participation of the affected communities (WMO 2008). Often, top-down approaches have not only resulted in unsustainable measures, which failed to meet the real needs of flood-affected communities, but in more severe cases led to serious disagreements, or even conflicts. It is increasingly recognized that top-down DRR measures often fail to address specific local needs and priorities of the most vulnerable communities, ignore the potential of local resources and capacities, and may in some cases even increase people's vulnerability (Abarquez and Murshed 2004). Local communities understand local problems and priorities better. By engaging with them, it is likely that the underlying causes of vulnerability to flood risk can be more effectively addressed.

International agencies, government and NGOs may initiate and implement flood risk management measures before and after a disaster. However, once the external support comes to an end, such initiatives may be neglected. To a certain extent this lack of continuity may be linked to the lack of participation, empowerment, and ownership by the local communities (Kafle and Murshed 2006). For example, small-scale flood mitigation measures and basic service provision improvements, such as for water and sanitation infrastructures, are often found to be unsustainable and are not scaled up. Agencies that implement flood mitigation projects often fear the cost of participation in terms of both time and money. However, community involvement in the planning and implementation of flood preparedness and mitigation can save wasted investment in inappropriate interventions in the long run. This was demonstrated in Malawi in Case Study 6.5 where the involvement of communities in risk assessment and planning provided extra resources to the project and led to better understanding of and commitment to the implemented measures.

By enabling communities to organize themselves and linking them with local decision-making mechanisms, the continuity of flood risk management initiatives can be maintained. It is recommended that decision making should be seen as a "combination of top-down and bottom-up approaches which enables the involvement of all stakeholders on the basis of equity" (WMO 2008: 34).

Case Study 6.5: Multi-stakeholder flood management in Malawi

Heavy rains in Malawi very often give rise to flooding. It is expected that changes in the seasonality and volume of precipitation due to climate change and variability may result in more flood events in the future.

In a project implemented by the NGO Tearfund in 2003, local communities in the area of Mthumba, Chikwawa District, in the southern part of Malawi, were engaged throughout the process of design and construction of small- to medium-scale flood prevention activities. This provided the communities with a better understanding of the rationale of flood prevention measures, which included the construction of structural measures, such as building storm drains and planting trees along the river to slow down water runoff, and involved a range of different actors, including the government and private companies.

Methods that were used included participatory assessment for disaster risk to identify the main type of hazards, their sources and their potential impacts, while communities were trained on environmental resource management, such us the use of vegetation to prevent river bank erosion. Moreover, historical data about the previous course of the river were gathered by the community elders, to better inform the choice of mitigation measures needed to re-establish the previous route of the river away from current community structures, like residences and shops.

This initiative shows that when communities are involved they can better understand flood hazard and flood risk. Moreover, ownership from the communities is necessary to guarantee long term sustainability of any initiative. Local governments need to engage with communities and also mobilize the necessary resources.

Source: Tearfund (n.d.).

6.3.2. Stakeholders involved in community engagement

It is crucial that the flood-affected communities and all other relevant stakeholders are carefully identified, as illustrated in Figure 6.4. Identification of stakeholders needs to consider potential differences or conflicts. It is important, therefore, that this is done in an inclusive manner.

Consulting and working with local governments is not only essential but also a democratic necessity. Often, international agencies that implement urban flood mitigation projects work with national or federal government bodies (for example Ministries, or Water Development Boards); they may ignore (or almost ignore) the municipalities or local authorities, mayors, ward councilors and commissioners. However, these stakeholders are particularly important to urban flood risk mitigation.

Box 6.4: Relevant stakeholders in urban flood risk management

- Communities which are affected by the implementation (or non-implementation) of measures
- Community based organizations (CBOs)
- Non-governmental organizations (NGOs)
- The responsible municipal authorities
- River basin organizations or authorities
- Regional development authorities
- Scientific institutions, including universities
- The private sector

Source: adapted from WMO 2008

Involvement of all relevant stakeholders is important because (WMO 2008):

- It brings knowledge and experiences from different perspectives together, and thus enabling a more insightful understanding of flood risks.
- Members of flood-affected communities have the chance to express their real needs and priorities, and promote the consideration of their demands in the decision-making.
- Stakeholder involvement ensures that a wide range of actors support the undertaken flood risk management measures, thus ensuring that they are sustainable.

Time constraints is an issue that needs to be considered by decision makers in relation to the involvement of communities and other stakeholders in flood risk management. The time that people, especially poorer people, have to participate in flood risk management measures, in public consultations and other activities, is often limited. Moreover, mobilization of the community to engage in voluntary service is also a challenge. For this reason, it is important to identify special means to facilitate people's participation. This is further discussed on Section 6.3.4.

Figure 6.4: Stakeholders and actors involved in flood risk management
Source: Adapted from Abarquez and Murshed 2004: 19

6.3.3. Understanding local knowledge and capacities

Communities often have first-hand experience of flood disasters. It is quite common for them to have developed coping mechanisms, such as local institutions and CBOs, to deal with adverse effects of flooding. However, the understanding and capacities of the local communities are often overlooked (Moga 2002).

Pioneering examples in community disaster mitigation include PREDES, the network for social studies on disaster prevention in Latin America, and Duryog

Nivaran, a network of organizations and individuals in South Asia which has been promoting community management and mitigation activities since 1994. Similarly, in South Africa, Periperi (Partners Enhancing Resilience to People Exposed to Risk) emphasizes disaster risk reduction by bringing in resilience to the community as a whole. The Asian Urban Disaster Mitigation program under ADPC, in collaboration with USAID, has also started the program of enhancing the resilience of selected cities in South Asia by encouraging community participation in resilience building to reduce vulnerability.

It is vital that flood risk management solutions acknowledge communities' existing ways of dealing with floods. Solutions should complement existing coping mechanisms, resources and social capital, and not compete with them (Alam 2008). Communities that live in locations where floods occur regularly will probably be more prepared than people living in areas where floods are rare. Often communities establish their own local and traditional institutions to deal with disasters, including flooding. These are discussed further in the section which follows on community-based measures. If external flood risk management support complements these existing mechanisms and local institutions, it is likely to be more sustainable after the external assistance stops (Sphere Project 2004).

In areas which have not or have rarely experienced floods, community participation and motivation in preparedness and mitigation activities is also important, as discussed above. However, experience shows that participation is difficult in an emergency (ActionAid 2002). Community engagement in flood risk management should strengthen people's sense of dignity, and also give hope in times of crisis (Sphere Project 2004). It can also contribute to equitable and sustainable community development in the long term (Abarquez and Murshed 2004).

6.3.4. Sharing of information and knowledge

Communities need to be well-informed about flood risks to actively participate in flood preparedness and mitigation. Information should be complete, unbiased, and minimize controversies (Creighton 2005). The sharing of information and knowledge among all the stakeholders involved is vital to better understand the problems and to provide coordinated assistance (Sphere Project 2004). In particular, communities and all other relevant stakeholders need information about the ways in which the undertaken measures could affect their livelihoods (Creighton 2005).

The process of engaging local communities in flood preparedness and mitigation requires information on flood risk and the recommended management measures to be generated in a manner and language that is understood by the local communities (Kafle and Zubair 2006). Moreover, mechanisms should be established to allow communities and other relevant stakeholders to comment on the undertaken measures, for example in public meetings or through CBOs. Specific provision should be taken into consideration for individuals who are confined to their shelters (disabled people, for example).

6.3.5. How to engage local communities in flood risk management

Engaging the concerned community in flood risk management will ensure that the public's real needs, priorities, resources and capacities are taken into consideration. Experience shows that that flood risk is more likely to be successfully reduced when the communities are fully engaged. The general problems observed in communities are a lack of appreciation of risk and a lack of motivation to participate in flood mitigation activities. At the same time, official agencies often do not appreciate the potential benefits of community participation and do not have the skills or experience in participatory activities.

Method

A step by step process for achieving effective engagement of communities in flood protection is outlined below. Communities should be involved in all processes of flood risk management, including assessment, planning, implementation, monitoring and evaluation. Community participation means that the management of flood risk is more effective and proactive.

The situation differs from one area to another as defined by social, economic, political and cultural context. It is important to ensure that these factors are taken into account when working with communities.

1. Raising awareness of flood risk and motivating community action

2. Strengthen relevant community institutions

3. Ensure inclusion

4. Planning for real

5. Actively encourage participation for sustainability

6. Monitoring and evaluation

1. Raising awareness of flood risk and motivating community action

Although the situation varies from one area to another, it is commonly observed that communities often lack an appreciation of the flood risk and hence have little motivation to participate in flood protection activities. Generating public awareness of flood risk is therefore core to successfully engaging communities in flood risk management.

Appropriate communication techniques should be selected dependent on the social, economic, and cultural context. Formal communications through pamphlet or leaflet drops will deliver information to people's doorstops. Motivation through radio and TV infomercials may work in some communities. However, in many communities more innovative participatory communications will raise awareness most effectively. Participatory techniques include group discussions, participatory mapping, Venn diagrams, timelines, transect walks and ranking exercises. It may be particularly effective to identify organizations which have ongoing engagement with the communities and work with and through them to introduce flood awareness and risk mitigation.

Public awareness of flood risk directly feeds into motivating them for flood risk management. Again different techniques will be appropriate for motivation in different communities. The facilitation of these participatory sessions will not be easy where there is little public confidence in the authorities' ability or interest in working with communities. For effective public participation it is essential to build trust and understanding between the community and the concerned professionals. This may take time and will require facilitation by experienced participatory communications expertise.

As awareness rises and motivation grows, weekly workshops perhaps using models and photo-montages to communicate and develop ideas, or group planning and design sessions which combine experts' and public's ideas will collectively develop technically effective risk mitigation solutions that meet local needs. Walkabout mapping exercises can be used by residents to highlight the perceived problems and possible benefits of risk management interventions. It is important to have representation from all sections of the community to ensure that all risks are identified and mitigated. Events (e.g., simulation exercises, big tent events, fete style events, town hall meetings, etc.) can be used to encourage local people to consider flood risk and make suggestions for possible changes or interventions.

Communities who face regular flood events will have their own indigenous methods of flood risk mitigation. It will be important for practitioners to understand, reflect and learn from these as building on existing mitigation mechanisms will often be the best starting point for encouraging active community participation. Exploiting existing expertise and building additional capacity within the local community will make the flood risk management work of professional bodies much easier. Effective community engagement will also enhance sustainability.

2. Strengthen relevant community organizations

For sustainability of any community engagement it is vital that there are appropriate active institutions of the community. There is usually a clear choice either

a) To identify an appropriate existing organization and bring flood prevention into their mandate, or

b) To establish a new flood-specific community organization.

Motivating existing active community organizations to focus on flood issues and providing them with training and any necessary technical skills will enable them to integrate flood risk planning and mitigation into their existing activities (e.g., health, education etc.). Starting a new community organization to work specifically on flood issues, in parallel with those that already effectively working on other community services, is likely to require significantly more input both at the start-up and to ensure sustainability.

Either way, capacity building input will be required to strengthen the concerned institution's knowledge base – specifically their understanding and appreciation of flood prevention activities to be undertaken by the community – and their management capacity. Training courses, exposure visits, transect walks, roundtable workshops – there are a range of possible interventions which will be appropriate to meet the institutional strengthening needs of any specific community organization.

One vital aspect is to ensure that the community organizations have open two-way communication with the concerned authorities. This will enable decision making to benefit by input from the community, and also for communities to activate the authorities should they require any official support.

3. Ensure inclusion

Whatever institutional arrangement is developed at the community level, the flood mitigation practitioners must ensure that all segments of the community are included.

As discussed elsewhere, floods have a differential impact within communities, often impacting the poorest and most marginal most (e.g., slum and squatter communities, settlements on flood plains or riversides etc.). Similarly, within any community, the aged, disabled, young mothers and children will have specific vulnerabilities which will need to be recognized and addressed. It is essential to ensure the involvement of the most marginal in any community engagement process. This may require detailed mapping to guarantee geographical coverage, and social mapping to ensure that any plan includes the most vulnerable. If representatives of these groups cannot be included at the institutional level, then these marginal groups should be specifically consulted on their flood experience and any anticipated difficulties which would arise for them. Any specific needs should be incorporated into planning.

4. Planning for real

This is an exercise which integrates in the planning process the local community knowledge with external expertise and any appropriate options presented by new technology. There are many ways to do this but central to the approach is that the professionals must be open to the input of local communities and communities should be confident that their voice will be heard.

Planning using normal paper-based plans and diagrams should be avoided as this does not facilitate understanding by non-technical participants. Models and pilot demonstrations are much more useful to elicit informed reaction from the community. Joint visits to other sites where any proposed flood measures have already been successfully carried out is an important motivational and planning tool. The experts can hear directly the local opinions on where and how such interventions might work in their community.

Where appropriate, the consultation and information sharing process can take advantage of web-based tools alongside any standard planning procedures and also invite the submission of written comments. Utilizing higher technology can make work easier and faster, however, if used inappropriately they can exclude people, especially the more remote and more vulnerable in the communities.

After detailed planning consultations, a participatory design review should be carried out to ensure local understanding and buy-in. This will be in addition to the standard good practice of having an expert review of the proposals.

5. Actively encourage participation and sustainability

It is vital that professionals recognize that community engagement is not a one-off activity but a process that requires sustenance and support. It should also appreciate that capacity building of the local community for flood risk mitigation will make the work of professional bodies much easier. Planning should include on-going mechanisms that support community self-help initiatives and motivate communities to sustain agreed activities or maintain operational readiness. This might or might not include funding. Provision of continuous education and training can be a good incentive. Regular dialogue and participatory status reviews are essential.

6. Monitoring and evaluation

A well-designed flood risk mitigation strategy will clearly define anticipated outcomes. These will be established as part of the planning process. The strategy should also incorporate a monitoring system to ensure effective implementation, and an evaluation process to assess impact and guide subsequent improvements. This monitoring and evaluation should also include participatory activities as communities are usually in the best position to know what worked and what did not. Professionals, especially technical professionals, often find it difficult to submit their interventions to evaluation by the public. However this is a vital dimension of community engagement in flood protection.

The concerned community will be able to record and report the impact of flood risk mitigation interventions, and most importantly is likely to understand the reasons for any failures, thereby provide feedback that will help avoid repeats. A well-designed monitoring and evaluation process will also be able to disaggregate the impact on different segments of the community. Again the techniques for recording community responses to a flood event will depend on the social, economic and cultural background of the local communities. In many places, participative consultation and evaluation techniques may well be the most appropriate.

There needs to be a feedback mechanism which ensures the monitoring and evaluation findings feed directly back into improved flood protection. If this is publicly acknowledged and community organizations are fully involved in the process, then it will further enhance public trust and community engagement.

6.3.6. Further reading

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6.4. Community-based measures to increase resilience

Community engagement, as seen above, is vital for effective flood risk management. In many instances, this should be complemented by community-based flood risk management measures, which can result in progressive improvements in public safety and community disaster resilience. The measures are specific to a community, in that they are identified, designed, implemented, monitored and evaluated by the community themselves, although very often with external technical and financial assistance.

The whole approach is based on the belief that local people can and will help themselves to prevent or reduce disaster risks.

The purpose is for a community to be prepared to face floods in the short term and for its members to be more resilient to floods in the longer term. This issue most frequently arises in communities which have a history of repeated flood events or have previously been flooded. Community-based flood risk management measures are based on using community resources to reduce the risk and impact of flood events.

6.4.1. Key components

The community is likely to be defined either by the geography of the flooding (for example, particularly low-lying or river-side settlements) or by administrative boundaries and the socio-economy of the urban area (comprising an electoral ward, neighborhood or housing colony). Either way, the spatial dimension is an essential element in defining the community that is at risk.

Communities are also complex and dynamic. People may join together for common goals and separate once they have been achieved (Twigg 2007). There will be differences in wealth, social status and employment of people living in the same area as well as, potentially, other more serious divisions within the community. Communities are likely to have worked together previously to manage other community activities, either informally (such as for festivals, sports clubs, clean up campaigns) or more formally for initiatives such as ‘neighborhood watch’ (a local security and safety program), garbage collection, crèches or health camps. It is vital that, if the initiative for undertaking flood mitigation measures comes from outside the community, the external agency researches the community activities which already exist within the area, as well the ways in which participants define the membership and boundaries of their community.

Good, strong, committed management is essential for effective community-based flood risk mitigation. Either an existing community organization will need to be trained and strengthened to take on this management role, or else a new organization will need to be built up during the process of risk assessment and mitigation planning. There is mixed evidence of the value of new community disaster management organizations, when formal or informal community organizations that might undertake the task already exist (Delica-Willison n.d). In either case it is clear that for management to be the most effective, both the management role and the tasks need to be clearly specified.

The community-based organization will need to ensure that the needs and priorities of the various stakeholders and different interest groups within a community are heard and balanced. Most particularly, to be effective, it must make sure that the more vulnerable segments – the women, children, elderly and disabled people, as well as any ethnic or otherwise marginalized minority groups – are given space to voice their opinions and are properly heard. Incorporating indigenous knowledge is also very important. The flood early warning system set up in eight villages in Dagupan City, Philippines, for example, has revived the use of the 'kanungkong' along with staff gauges as flood markers in strategic locations in the villages of the city.

The kanungkong is a bamboo instrument, which was traditionally used to call community members to assemble at the village hall for meetings, alert people or call children home. The indigenous knowledge is combined with modern scientific knowledge and equipment for use in disaster risk reduction (ISDR 2008).

The use of indigenous practice is also illustrated in the following Case Study 6.7 from Bangladesh.

Case Study 6.7: Learning from grassroots coping strategies for climate variability in Dhaka, Bangladesh[1]

Valuable lessons can be drawn from grassroots experiences of dealing with environmental hazards to reduce vulnerability. Understanding such local responses can contribute to the strengthening of planning strategies for adaptation to climate change and variability in cities.

Primary research carried out in Karail, the largest informal settlement in Dhaka, by the Development Planning Unit at University College London (UCL) in co-operation with BRAC University in Bangladesh, examined household and collective adaptation strategies to cope with existing environmental hazards such as flooding.

1 http://www.bartlett.ucl.ac.uk/dpu/adaptation_to_climate_change_in_cities

Photo 6.1: Informal settlements in Karail, Dhaka, Source: Huraera Jabeen

In 1988, 1998 and 2004, Dhaka experienced major floods that were caused by overflowing of the surrounding rivers. People living in Karail, however, experience environmental hazards nearly every year due to increased rainfall and flooding. The research found that local coping strategies that have been adopted either at the household or community level to reduce vulnerability include:

- Physical modifications (higher storage, increasing the height of furniture, installing rain gutters, making barriers at the door front, changing building and plinth materials after the disaster)
- Savings and access to credits (half of the households save regularly with a savings group or an NGO)
- Diversified income sources (households with diversified income sources are less vulnerable to floods)
- Strong social networks (37 percent of the households are part of some form of social network and can seek assistance in case of emergency)
- Accumulations of assets (saleable household assets, building materials, investing in children's health and education).

To mainstream local coping strategies into flood risk management and urban planning there are several aspects that decision and policy makers can take into consideration. First, it is important to integrate local knowledge to define patterns of vulnerability. Second, adaptation plans can be embedded into wider development goals. Third, risk transfer mechanisms for low income groups, such as collective savings schemes and insurance should be supported. Last but not least, a combination of "structural" and "non-structural" approaches developed by partnerships of government, utilities and civil society should be instigated.

Source: Jabeen et al. 2010.

Led by the CBO, the community will carry out a disaster risk assessment and prepare a disaster management plan. There are several useful and very detailed guidelines for these two key activities referenced at the end of this Section. Based on their disaster management plan, the CBO will ensure that a number of preparedness, emergency and recovery activities are carried out. Examples are listed in Box 4.8.

Box 4.8: Possible community-based flood risk management activities

- Flood preparedness
- Conduct disaster preparedness training with community members
- Raise community awareness on what to do before, during, and after a disaster
- Monitor disaster threats, conduct drills, and draw lessons to improve the plan
- Network and coordinate with local government authorities, government disaster management agencies, NGOs, other communities
- Engage in advocacy and lobbying work regarding disaster management to support community preparedness and resilience
- Expand community involvement in disaster risk management and activities.
- Flood emergency
- Issue warnings and manage any necessary evacuation
- Organize search and rescue with community participation and external assistance, as required
- Provide first aid and arrange subsequent medical assistance
- Conduct damage needs capacity assessment and report both damage and needs to government and disaster management agencies for assistance

- Coordinate, plan and implement relief delivery operations with aid agencies
- Recovery
- Facilitate social, economic and physical rehabilitation of the community; e.g. livelihoods, trauma counseling, reconstruction of houses and infrastructure
- Coordinate with government and aid agencies to receive assistance in rehabilitation
- Ensure that risk reduction measures are integrated during the reconstruction and rehabilitation phase
- Evaluate the performance and identify strategies for future improvement.

Source: adapted from Abarquez and Murshed 2004.

6.4.1.1. External Support

The initiative to mobilize community-based flood risk management may originate from the community or from an external agency. Either way, it is quite likely that external agencies will be involved in the process. If, however, the interests of professionals rather than those of the community dominate the stakeholder groups or the discussions, and the agenda revolves around of a set of pre-defined professional objectives, then the process will be flawed (Fetzner–Wilson 2009).

To support or promote community-based measures, it is vital that any external agency works in ways which ensure the interventions address specific local needs of the vulnerable community and recognizes and builds on the potential of local resources and capacities. The external agencies must be sensitive to maintain community leadership in the process and not come with pre-prepared interventions, for which they are simply seeking local support. As recently argued, “programs that directly support communities and their local organizations have proved to work best for immediate reinforcement of coping and resilience capacities” (Bhatt and Aysan 2008).

6.4.1.2. Institutional Responsibility

However effective or efficient the community-based measures become, it should be noted that this does not reduce the overarching institutional responsibility of government for flood risk management. To acknowledge and support this, it is therefore incumbent on community organizations to keep government authorities fully aware of their priorities and activities.

Similarly, the government should acknowledge that they cannot have effective risk mitigation without mobilizing the cooperation of residents and their community organizations. In all flood management measures, the objective must be for different stakeholders to work in productive partnership and all partners should take responsibility for promoting this.

6.4.1.3. Evaluation, Lesson Learning and Federating between Community Organizations

Effective and sustainable actions include transparent monitoring and evaluation procedures. Particularly after any significant flood event, an independent but participative evaluation of the effectiveness, efficiency and impact of the various flood mitigation measures undertaken by the community is very instructive. Full disclosure to the community is essential, as any positive lessons will directly strengthen support for the approach and enhance sustainability of the measures, while any negative lessons must be seen to inform improvements to the system.

Dissemination of evaluation findings is fundamental to improving practice through lesson learning and sharing. This can be formalized by creating links between CBOs, perhaps through a federating or coordinating body, so that lessons from one area immediately and effectively inform the activities undertaken in another. There is no more helpful way of learning than doing so from a peer group.

6.4.1.4. Grievance Redressal

Well-managed community-based flood risk mitigation is likely to be the most appropriate and effective within the resources available. However, some people's interests might not be protected to the expected extent. In anticipation of this, the CBO should establish a grievance redressal mechanism. It will most probably require a committee, formed in association with representatives of local government and locally respected persons, ensuring an appropriate gender and social balance (Prasad 2005). The existence of the mechanism must be well-publicized in the community; when any lapses are reported, the CBO should facilitate the redress of the grievances to the satisfaction of the concerned parties, through the established mechanism. This will help maintain harmony and mutual trust between residents, and will be an important factor in the long term effectiveness of community-based measures.

6.4.1.5. Legislative and policy changes

If the community-based approach to flood management becomes widespread and popular, it may be valuable for the relevant government to consider legislation to formalize the CBOs' role and status in this regard, and establish policies to ensure their proper consultation and participation in larger scale structural and non-structural flood management activities.

6.4.1.6. Sustainability

Several commentators note that, due to funding constraints, disaster risk management work by agencies and smaller NGOs is often unsustainable and not scaled up. As a route to longer-term success 'strong engagement with the community' has often been proposed (as discussed by Alam 2008 and Moga 2002 amongst others). This rather begs the question of how the sustainability of community-based actions can be ensured.

Communities are certainly capable of initiating and sustaining their own development. Flood risk management does not need to be any different, but the following are important to increase the likelihood of both success and sustainability:

- The short and long term benefits should be clear to all concerned.
- Strong involvement of all stakeholders is needed in determining risk reduction priorities and mitigation options (Abarquez and Murshed 2004).
- Good participatory processes within the community and between any external agency and the community are required (as discussed in detail by Abarquez and Murshed 2004; Prasad 2005; IFRC 2007 and Creighton 2004) .
- Include specific indicators of sustainability when establishing the monitoring and evaluation processes.

6.4.2. When and where to use Community-Based Measures

On the positive side, most urban environments have considerable strengths in terms of economic production and distribution, human resources, social capital and civil society. Cities in fact are by definition 'resource-rich' – the wealth of human and social capital in cities is part of what draws people to them and should be used to support humanitarian response, recovery and development throughout disaster-response efforts (O'Donnell and Smart 2009). Community-based measures are appropriate wherever urban communities face flood risk and are interested in working together to lessen the impact of those risks. There are examples in many countries, both developed and less developed, and in richer and poorer communities within those countries.

The approach is probably most valuable in low-income informal settlements for three reasons:

- Assets function as a buffer to help people cope with disasters; however poorer people have fewer assets, so they rapidly become more vulnerable to the next flood (Alam 2008).
- Ongoing development initiatives in these communities (for example, basic service provision, health awareness, and financial services) will benefit from incorporating disaster risk management into their development strategies.
- It is often more problematic for formal government-led interventions to reach into these poor communities.

For the latter reason, any such measures should include, as an important component, building and strengthening the flood risk management partnership between the community organization and local government authorities.

6.4.3. Benefits

Community-based measures can be of many different types and at different scales of operation, leading to different contributory benefits. However, the overall benefit will be the sustainable reduction in the impact of flood events.

Successful community organization for flood management may lead to other parallel, related interventions, such as improved environmental management or ongoing support for the community's most vulnerable members. Success in disaster risk management can only strengthen the community, which then has the potential to lead to further activities for the community's wellbeing and development.

6.4.4. Drawbacks

A number of limitations can affect measures:

Scale: community-based measures by definition work at the community level so, although the approach can be carried out in a number of communities, and communities may be networked into a larger federation, it is not by its nature a large scale or citywide intervention.

Coordination and Communication: coordination is a major challenge in any disaster event. The involvement of numerous community-based organizations could further exacerbate this challenge unless effective systems for communication and coordination are agreed upon and put in place as part of the preparedness planning. Working to build good relations between CBOs and official agencies and among CBOs (see discussion of networking above) while carrying out flood preparedness activities will be fundamental to effective coordination and communication during a subsequent disaster event.

Sustainability: this is a key challenge. Many disaster risk management approaches are built on the assumption that informing the individual or community about a hazard will lead to awareness, and awareness to action, and that will result in sustained behavioral change. In practice it is not always so simple. Stakeholders perceive risk differently, and people do not believe that all risks are of the same type, size or importance (Abarquez and Murshed 2004). Sustainability is discussed above as one of the key components requiring special attention in any community-based measure.

Accountability: there is a risk, especially if significant resources become involved, that the CBO may be hijacked by certain more powerful interests. Maintaining both the community-wide quality of the measures, and also the full transparency in all dealings, are essential for the credibility and sustainability of community-based measures.

Coverage: including the most vulnerable is a challenge. For example, orphans and street children in urban areas may be invisible to external agencies working either for flood preparedness or emergency relief. Community-based measures may recognize them as a particularly vulnerable group and, in coordination with local organizations already working with orphaned and street children, may be able to ensure that these children are included in formal programs (O'Donnell and Smart 2009 and WFP 2002).

6.4.5. Essential considerations

Community-based measures must build productive partnerships with local government and be aligned with the official flood risk measures which are often being implemented in parallel. The initiative for this partnership can come from either side, but both partners must recognize this as essential for coherent flood risk management: the community cannot manage in isolation from the local authorities, and the authorities' own measures can only benefit from close cooperation with local communities.

Without external technical and financial support community-based measures will remain small. This support may come from government, local government, NGOs or international donor agencies. This is discussed below and it is only repeated here to stress the need for any external support to be balanced against the inherent community-driven nature of the approach. Whatever support is provided should, with appropriate oversight, leave the community to guide and manage the process.

6.4.5.1. Guidelines for Community Disaster Management Activities

Abarquez, I. and Murshed, Z. 2004. "Community-based disaster risk management: Field Practitioners' Handbook." ADPC.

Creighton, J. 2004. "The public participation handbook: making better decisions through citizen involvement." Wiley, San Francisco.

ISDR. 2008. "Indigenous knowledge for disaster risk reduction: good practices and lessons learned from experiences in the Asia-Pacific region." UNISDR, Bangkok.

Prasad, K. 2005., "Manual on community approach to flood management in India, Associated Program on Flood Management." WMO/GWP.

Twigg, J. 2007. "Characteristics of a disaster-resilient community, a guidance note, DFID Disaster Risk Reduction Interagency Coordination Group." DFID, London. http://www.benfieldhrc.org/ disaster_studies/projects/communitydrrindicators/community_drr_indicators_index.htm.

Shaw, R. and Okazaki, K. ed. 2003. Sustainability in grass roots initiatives: Focus on community based disaster management. Hyogo, UNCRD. http://www.hyogo.uncrd.or.jp/publication/pdf/GrassRoots.pdf.

6.5. Financing flood risk management measures

6.5.1. Financing integrated flood risk management

The choice of flood risk management and mitigation measures will also be critically constrained by the available resources to implement the chosen scheme. As an illustration, in England and Wales, the Environment Agency has powers for both the provision and maintenance of flood defences and detailed risk reduction project evaluation guidance. The number of eligible projects, however, far exceeds the funds available to the Agency to carry out those projects. National government, which has responsibility for allocating funds across competing priorities, of which flood defense is a very small part, is currently limiting the resources available. Wamsler (2006) notes that funding for integrated risk reduction and urban planning measures may be constrained by non-existent or insufficient financial support, or because funding is allocated towards non-integrated risk reduction or planning measures. In low- and middle-income countries, the constraint on funding is even greater.

Governments, which may be highly reliant on development assistance, may find that the best opportunity for fund raising is generally after the disaster. Data shows that between 2000 and 2008, about a fifth of total humanitarian aid was spent on disaster relief and response; in 2008, only 0.7 percent was put towards disaster prevention (World Bank 2010). However, flood and other disaster risk reduction activities are long-term processes that increase the sustainability of development interventions, and donors therefore need to incorporate this perspective into their plans and programs.

In most developing countries, city government authorities lack the resources to invest in new infrastructure; they tend to rely on funding from higher levels of government to finance improvements in service provision, including flood risk reduction (Parkinson et al. 2003). The urban poor also lack the financial resources to invest in improved housing, which would increase their resilience to flooding. Lack of access to the credit or the insurance market is another factor that reduces their capacity to cope with flood events. Moreover, those with a lack of secure tenancy may lack the incentive to invest in better housing in order increase their resilience to flooding.

One key constraint is that sometimes there is no real demand for implementing effective systems for flood risk management; as a result there is generally little willingness to invest. This may relate to a lack of awareness of flood risk and of the implications relating to flood disasters. However, it is a commonly held myth that awareness of flooding will engender a desire to respond to, or a willingness to comply with, flood management measures. Populations and institutions can be focused on short-term certainties rather than long-term possibilities and therefore mandatory compliance or strong incentives may be needed.

The fact that flood risk management measures may not offer quick returns to donors and governments can further limit available funding opportunities. It can, therefore, be helpful to link flood risk management with poverty reduction and climate change adaptation, or with more specific issues of urban planning and management such as housing, land tenure, and basic service provision and infrastructure. Robust solutions can contribute to flood risk reduction, while at the same time addressing wider development objectives. Nevertheless, to integrate flood risk reduction objectives within urban planning in general will first need flood experts and development practitioners to find a way to fit with the "current language of policymakers" (Wamsler 2006).

The large amount of financial investment required to implement flood risk management schemes is often regarded as a major constraint. Adaptation to flooding is one of a number of competing priorities for overstretched national, local and individual purses. Moreover it is one which does not usually provide immediate visible benefits to populations. The notion of "Not in my Term of Office" may lead to politicians and government officials placing flood risk management lower on the agenda than other, more tangible or immediate programs, and deferring or delaying action. Often it is observed that funding for flood risk management is most available after a flood event when public pressure demands action. Therefore, in many instances, financing of measures to reduce flood risk is closely related to the previously discussed topic of insurance and recovery, as measures are implemented in the aftermath of disasters and use disaster recovery or insurance payouts.

However, this can be seen as an inefficient approach and 'ex ante' flood prevention must also be considered within the holistic context of the costs and benefits of pursuing alternative strategies to managing risk. When the full range of available measures detailed in Chapters 3 and 4 are considered, it becomes clear that flood risk management spending does not always have to be explicit: it can be form part of broader development spending, climate change adaptation spending, integrated water projects, slum upgrading, or education. Disaster risk spending is also to some extent already mainstreamed into the work of multiple departments and agencies (Jackson 2011). Capital investment in large sale engineering projects specifically to address the risk of flooding may be in the minority but these also require funding mechanisms.

Decisions about the source of financial support for flood risk management need to be based on the distribution of costs and benefits arising from such investment – and also upon the capacity of individuals, governments and other stakeholders to make a contribution. Thus, in the developing world, it may be assumed that the largest financial impacts from flooding are currently borne by government in the form of infrastructure damage; likewise, the major burden of flood mitigation spending will also be placed on governments, who must find the money from a wide variety of sources. A first source of funds for national programs is naturally the tax base, but in developing nations this may be a severely limited natural revenue stream.

It has been estimated that the capacity of developing countries to invest in their own adaptation strategies will not meet their needs. External sources of funding in the forms of debt, equity, grants, lease financing, loans, overseas development assistance, payment for ecosystems services, risk management, structural finance and technical assistance, are also necessary. The international community is therefore a key partner in flood risk reduction. This section considers the various established international funding options, but also looks at other sources of financial support.

6.5.2. Grants and Loans from international development funds

The provision of development funding grants from international donor organizations towards flood management programs has been significant over decades. Many large-scale programs have been developed, for example, the Global Fund for Disaster Reduction and Reconstruction (GFDRR) has recently funded NADI, a program towards integrated flood management in the Pacific.

Table 6.1 below lists some of the donor agencies and their focus areas. In the past there has been an emphasis on large-scale structural measures in the form of engineering works, but agencies are moving towards a more integrated approach. The focus on funds for provision of warning systems, for example, is a recent welcome development. The list below is indicative as new and emerging focus areas may evolve in the future.

Table 6.1: Donor agencies and focus areas

Canadian International Development Agency http://www.acdi-cida.gc.ca/home	Mandated to support sustainable development in developing countries to reduce poverty and contribute to a more secure, equitable, and prosperous world.
Deutsche Gesellschaft fur Technische Zusammenarbeit (GIZ) http://www.giz.de/en	An international cooperation enterprise for sustainable development with worldwide operations. Its corporate objective is to improve people's living conditions on a sustainable basis.
The World Bank/International Development Association (IDA) http://www.worldbank.org/	IDA aims to reduce poverty by providing interest-free credits and grants for programs that boost economic growth, reduce inequalities and improve people's living conditions
OPEC Fund for International Development (OFID) http://www.ofid.org/	Supports finance for development in Sub-Saharan Africa
Islamic Development Bank (IDB) http://www.isdb.org/	Fosters the economic development and social progress of member countries and Muslim communities individually, as well as jointly, in accordance with the principles of Sharia (Islamic) Law.
USAID http://www.usaid.gov/	Supports long-term and equitable economic growth and advances US foreign policy objectives by supporting: Economic growth, agriculture and trade; Global health; Democracy, conflict prevention and humanitarian assistance.
Development Bank of South Africa http://www.dbsa.org	Its purpose is to accelerate sustainable socio-economic development by funding physical, social and economic infrastructure. DBSA's goal is to improve the quality of life of the people of the region.
European Bank for Reconstruction and Development (EBRD) http://www.ebrd.com/pages	Supports projects from Central Europe to Central Asia, investing primarily in private sector clients whose needs cannot be fully met by the market, the Bank fosters transition towards open and democratic market economies.

Japanese Bank for International Cooperation http://www.jbic.go.jp/en/	Sustainable and sound development of the international as well as the Japanese economy.
US Trade and Development Agency (USTDA) http://www.ustda.gov/	An independent US Government foreign assistance agency that is funded by the US Congress. Helps companies create US jobs through the export of US goods and services for priority development projects in emerging economies.
Asian Development Bank (ADB) http://www.adb.org/default.asp	An international development finance institution whose mission is to help its developing member countries reduce poverty and improve the quality of life of their people.
AusAID http://www.ausaid.gov.au	The Australian aid program aims to assist developing countries reduce poverty and achieve sustainable development, in line with Australia's national interests.
DFID http://www.dfid.gov.uk/	The agency that manages Britain's aid to poor countries and works to get rid of extreme poverty. Working to reach the Millennium Development Goals (MDGs), the international targets agreed by the United Nations (UN) to halve world poverty by 2015.
EuropeAid http://ec.europa.eu/europeaid	EuropeAid Development and Cooperation is responsible for designing EU development policies and delivering aid through programs and projects across the world.
UNDP http://www.undp.org/	Integrating environment and sustainable development, including climate change, in national development planning and implementation is central to UNDP's poverty reduction and MDG mission

6.5.3. Climate change adaptation schemes

Another source of flood adaptation funding is from specific commitments to climate mitigation and adaptation funds. Although inadequate to meet the total needs of developing nations, the international community has committed significant funds to this purpose. New funding pathways are currently being developed, some of which fall under traditional overseas development assistance, whilst others are coordinated under the United Nations Framework Convention on

Climate Change (UNFCCC) (IFRC 2010). Spending on flood adaptation can be justified under these schemes, although there may be difficulty in apportioning the element of costs directly related to climate change (Pielke 2006). There may also be a lack of clear mechanisms through which international climate change adaptation funds can be transferred to local governments.

Funds are available both for mitigation and adaptation. Both sources may be appropriate for flood risk management schemes. For example, it may be possible to access the funds for ecosystem services, in order to implement natural flood protection buffers such as forests (which also contribute to mitigating reforestation targets). Defense barriers are more appropriately managed under adaptation funds. Examples of potential climate funding sources are shown in Table 6.2.

Table 6.2: Climate funding sources

Name of the fund	Accessibility for humanitarian actors	Relevance and potential for humanitarians	Current size of the fund
UNFCCC Adaptation Fund	Direct and Indirect	High	Net funding US$ 23.53 million with significant extra envisaged
Japan Cool Earth Partnership	Direct	High	Up to US$ 2 billion pledged for adaptation
Global Facility for Disaster Reduction and Recovery	Direct	HIgh	US$ 135 million contributed
German International Climate Initiative	Direct	Medium	US$ 162 million/year earmarked for developing and transition countries
UNFCCC Least Developed Countries Fund	Indirect	High	US$ 180.8 million pledged
European Commission Global Climate Change Alliance	Indirect	High	US$ 187 million deposited. In addition US$ 240 million will be used for DRR to serve the objective o the alliance

World Bank Pilot Program for Climate Resilience	Indirect	Medium-low	US$ 614 million pledged
UNDP-Spain Millennium Development Goals	Indirect	Low	US$ 90 million deposited. Further funding may be forthcoming from the US$540 million pledged

Information on climate funding sources is also available from the following website: http://www.climatefinanceoptions.org/cfo/Funding%20Sources.

6.5.4. Insurance measures including government, private and micro-insurance schemes

Insurance schemes have been previously discussed in Chapter 4. The role of such schemes in providing funding for flood management measures is covered here. Flood insurance can be a mechanism for providing cash in the aftermath of a disaster. This cash can be used to finance reconstruction in a flood resilient manner, particularly if this can be achieved in a cost-neutral way. Where flood protection will increase the cost of reconstruction, then many insurance schemes will fail to contribute. For example, in the UK the privately provided insurance cover for households has been seen to restrict the investment in resilient reinstatement (Lamond et al. 2009). To some extent regulation could address this problem. However, it could also be possible to use the power of insurance to bring in private funds for flood reduction measures by providing an incentive via restriction of cover, excess payments and premium incentives.

6.5.5. Foreign direct investment

The amount of inward direct investment is greater than the funds available through Overseas Development Assistance (ODA) by a factor of four (Bouwer and Aerts 2006). If such investment can be used for flood risk management, either via incentives or regulation, this could make a significant contribution to national resilience. For example, the bank HSBC has recently worked with city partners to deliver climate mitigation programs such as renewable energy in schools.

6.5.6. Public-Private-Partnerships

This aspect of funding, using the 'win-win' impacts of some flood prevention activities which may benefit private businesses, may be of more relevance in developed countries. However, many examples of Public-Private-Partnerships (PPP) also exist in the developing world. Examples of such multi-purpose flood prevention activities include dams which generate electricity and control flooding; and warning systems which may allow electricity companies to make better predictions. Tourism providers may also benefit greatly from the security of coastal warning systems.

Two cases of PPPs are illustrated below in Case Studies 6.8 and 6.9 below.

Case Study 6.8: Flood control in the city of Córdoba, Argentina

The drainage system of the city of Córdoba currently has 28 ha of retardation basins to attenuate surface flows. This area rises to 102 ha if the retardation structures associated with new urban developments currently at the design stage are included.

On-site observation during rainfall events and an analysis of reports indicate that so far there have been no problems with the hydraulic operation of these structures. The basins constructed in the 1990s are linked to existing storm drains, which act as a collector system. A small number of the planned structures discharge by overflowing into ditches.

Most basins have so far been built by private enterprise, and are generally linked to large industrial plants and supermarkets. These are usually small structures, each with its own maintenance requirements. In some cases, as a result of a good maintenance plan, there is very good integration with the surrounding urban environment which serves to minimize potential environmental problems.

The larger basins have so far been built and maintained by the municipality. They typically present a worrying environmental problem: contamination by liquid and solid residues (grey water, accumulation of refuse and the like.) that cause odors and may carry disease deterioration of the infrastructure (erosion of banks, sedimentation and so forth) and the presence of weeds and mosquitoes. In short, they are poorly integrated into the urban and suburban environment.

The Córdoba case demonstrates the way in which the private sector can be involved in the implementation of flood risk management measures, such as small retardation structures.

Source: Tucci 2007.

Case Study 6.9: Alandur Sewerage Project, India

The Alandur Sewerage Project (ASP), initiated in 1996 by the Alandur municipality, is a PPP directed at providing sanitation services to the city of Alandur in India. Alandur is a suburb of the Chennai Metropolitan Area (CMDA), which has a population of more than 125,000 with approximately one quarter of those living in slums.

Because the municipality needed resources, both in financial terms and technical expertise to undertake such infrastructural projects, the construction of the sewerage system was done under Bill of Quantities (BOQ) basis, and the sewerage treatment plant under Build, Operate and Transfer (BOT) basis, which is a type of arrangement in which a contractor builds the project, operates it and eventually transfers ownership of the project to the government.

In addition to the construction, the contractor also had to undertake operation and maintenance (O&M) of the sewerage system for a period of five years from the date of completion of the construction, on a fixed fee basis. The collection of tariff and provision of new connections during the O&M phase would be undertaken by the municipality.

A ‘Willingness to Pay’ survey, which covered more than 10 percent of the city’s population, was conducted by the consultants in order to assess the scheme’s acceptability by the residents. It was found that about 97 percent of the people wished to have the sewer connection and would be willing to pay a reasonable amount for the service. According to the survey, people would be willing to pay up to Rs 2,000 (US$ 44) for connection and Rs 21-50 (US$ 0.5-1.1) per month for maintenance, as in the case of water supply.

The municipality revised the initial tariff structure, and reduced the ceiling limits on the basis of the ‘Willingness to Pay’ survey and discussions with residents and municipal officials. In addition, the municipality issued a public notice in the local newspapers and the television in order to raise the awareness among the public about the project. As per the available information, all the civil works related to these service lines are completed.

For the success of such projects, a real ongoing commitment towards the project prior to implementation, political will and strong decision making are all preconditions. In addition, procedures in the bidding and contracting should be transparent and accountable, while stakeholder involvement and interdepartmental (horizontal) coordination further contribute to the successful implementation of the project. Finally, awareness campaigns were key components of the project, as communities supported the initiative, including the fact that about 29 percent of the project cost was covered from public contributions.

Sources: Mathur 2002; IWA Water Wiki (no date);
Government of India (no date); NIUA 2001.

6.5.7. Incentives for individual private investment

The insurance mechanism has already been mentioned as one method of encouraging private investment in flood resilience. Other potential schemes in place or suggested include tax incentives such as the abolition of sales tax on flood mitigation products such as flood doors, flood gates, flood boards. flood vents and pumps.

6.5.8. Integration of polices and activities

The selection of robust solutions which can be incorporated within existing programs, departments and agencies can result in an increase of funds into flood risk management. Solid waste management is a possible example of this practice: not only can waste management provide many health and environmental benefits but can also, potentially, generate some revenue and reduce the impacts from flooding. Arguably, this will be most effective at a local level where the need for such management is most apparent (Jackson 2011).

6.5.9. Charitable funding

Charitable NGOs channel donations from private and institutional donors to 'ex post' disaster relief to a significant extent, but also invest in 'ex ante' prevention. Often such agencies can be key players in engaging the community in flood risk management as part of wider outreach activities. A recent example of charity donations funding flood risk mitigation was the retention of some disaster relief donations from Hong Kong towards the construction of flood resilient housing in China (Lamond and Proverbs 2009).

6.5.10. Market-based loans

International loans for specific infrastructure projects are common. The structure of such loans is complex and they are typically of long duration. As such the banks usually require credit guarantee which is provided by organizations such as the World Bank and Export Credit Agencies.

Individuals or communities may also acquire funds for property level adaptation or local community schemes. This may be based on mortgage finance or security-backed loans. However, many individuals and communities in the developing world have difficulty in accessing finance via traditional market-based routes, and may rely on microfinance.

6.5.11. Microfinance

Microfinance arrangements have the potential to empower individuals and communities to implement flood risk management solutions for themselves. They can form a vital part of development strategy (ADB 2000) as they provide a broad range of financial products to poor individuals and micro enterprises. Microfinance can be supplied by market based financial institutions (MFIs), and also by NGOs for the poorest sectors of the population. Sri Lanka has a long tradition of microfinance (with more than 15 million deposit accounts and 2 million loans in 2005 from a population of 20 million); providers include the national government, commercial banks and finance companies, cooperatives, NGOs, and informal providers such as money lenders and shopkeepers.

A community-owned disaster fund can be set up which can accept funds from multiple sources including micro investments from the community. Allocation of grants and micro credits towards flood or other disaster mitigation can be determined by the community organization controlling the fund.

The Indian SEWA housing program supports individual loans for pre-disaster monsoon-proofing of homes, as well as loans to repair roofs, walls or doors damaged by floods. Through the Mahila Housing SEWA Trust, SEWA also supports community financing in urban slums to protect against future flooding by improving drainage and sewerage systems (O'Donnell 2009). Other schemes exist in Bangladesh, (as shown in Photo 6.2) El Salvador and Nicaragua in which MFIs have extended their portfolios to include loans for housing repair or reconstruction.

Photo 6.2: Microfinance via women's group in Bangladesh, Source: Shehzad Noorani

6.6. Sustainable maintenance systems

The section discusses the role of sustainable operation and maintenance systems once structural works have been completed. The cost of operation and maintenance is a critical aspect in the long term, so there will be a preference for designs that minimize maintenance. Realistic ways of revenue generation for sustainability and general awareness from the public and local authorities will be key issues.

Flood mitigation infrastructure requires regular repair and maintenance on a risk-assessed basis, so that the most critical elements are inspected and maintained and repaired at the most frequent intervals.

6.6.1. Operation and maintenance considerations for structural works

Unfortunately, despite appropriate design, high maintenance requirements are often introduced at the procurement and construction stages through the constraints of the bidding process, poor contractual enforcement, and the desire for low-cost solutions with little regard to subsequent upkeep. The maintenance requirement may not become obvious for some years after construction when project funds have been finalized and the maintenance responsibilities passed to the municipal authorities.

All structural measures should therefore be:

- Designed to minimize maintenance requirements.
- Use local materials and processes where these do not jeopardize construction quality.
- Be procured from reliable suppliers and contractors and not necessarily at the lowest price.
- Constructed under a precise contract adapted to the specific works with enforceable penalty clause(s) for non-compliance.
- Framed to include an extended maintenance element so that the contactor has a responsibility for rectifying any failures resulting from the use of poor materials and construction practices.
- Supervised by independent organizations capable of enforcing the contract without prejudice.

It is recognized that these are ambitious objectives but their implementation can improve sustainability by reducing maintenance requirements.

6.6.2. Maintenance of flood prevention infrastructure

Structural solutions including flood protection infrastructure needs to be maintained by:

- The de-silting and dredging of drains and watercourses to reinstate their natural or design capacity.
- The regular inspection of flood protection walls and levees for signs of structural failure and repairing these.
- The maintenance of pumps and ensuring sufficient fuel available for their operation during a flood event through regular inspection and test operation.

The Jakarta Globe (14 July 2009) reported that, if Jakarta's rivers and canals had been dredged regularly, the number of people directly affected by the 2007 floods would have dropped from 2.6 million to one million.

Maintenance should be undertaken at regular intervals and at low flows, before any significant seasonal rainfall.

6.6.3. Waste management and drain cleaning

The need for continued effective waste management to prevent the restriction and blockage of drains was discussed in some depth in Chapter 4. Briefly, this requires the following approach:

- Educating the community on the adverse effect of poor waste disposal
- Training of municipal workers and commercial concerns not to deposit waste in the drains
- The relocation of informal settlements and encroachments which may hinder the cleaning of the drains
- Effective enforcement of relevant land use regulations preventing the above from developing
- The provision of effective waste management services in informal settlements
- Monitoring of drainage effectiveness.

In Faisalabad, Pakistan drain volumes are drastically reduced as a result of the washings from small foundry workshops: these deposit significant volumes of foundry sand in the drains. The narrowness of the lanes prevents access by mechanical equipment, so that the drains have to be excavated manually. No enforcement mechanism has yet been found to stop this recurring after the drains have been cleared.

Maintenance requirements should be a key element of the design of the structural works. The main drainage channels should be:

- Designed to allow self-cleaning by maintaining low velocities even during the dry season by "benching" so that low flows are contained within a narrow channel in the center of the drain and larger flows are accommodated by the entire width of the drain.
- Lined channels to maintain flow velocities and prevent erosion, and to deter encroachment and restrict vegetation which would slow flows.

– Designed with access for maintenance by providing a track alongside at least one side of the drain.

– Designed with local materials so that repairs can be made quickly and cost-effectively. For example, the lining of a drain in Lahore (Photo 6.3) represents good practice by using bricks which are abundant locally; they are cheap and their use is familiar to every laborer.

Photo 6.3: The retrofitting of a lining of local bricks along a drainage ditch in Lahore Pakistan. Accumulated debris, sediment and vegetation has been removed from the ditch, the bank re-profiled. Source: Peter Lingwood.

6.6.4. Planning regulation, enforcement and integration of policies and activities

The importance of planning regulations as a tool in spatial planning and reducing vulnerability has been described above. However, one of the most prevalent and insidious forms of unplanned development is though progressive encroachment which may:

– Prevent effective drain cleaning.

– Reduce drain capacity through covering or even infilling of drains.

– Impair the effective operation of flood protection measures.

– Specifically affect low-lying areas which are at greater risk of flooding.

6.6.4.1. Integration of policies and activities

Political commitment is a precondition in order to facilitate the allocation of resources for integrated flood risk management, and to strengthen the capacity of the most vulnerable communities to cope with flood risk. This commitment should be implemented through policies and institutional frameworks that explicitly incorporate flood risk concerns (AfDB et al. 2004).

The integration of flood risk management into wider development plans is vital because city governments cannot afford to ignore risk considerations, particularly those related to climate change, unplanned urbanization and environmental degradation. Dagupan City in the Philippines demonstrates a successful example of community resilience to flood and tropical cyclone disasters (ADPC 2010). It is one of the few cities that mainstreamed DRR into local governance during the implementation of the Program for Hydro-Meteorological Disaster Mitigation in Secondary Cities in Asia (PROMISE). Absence of integrated DRR in many low- and middle-income countries may be linked to the failure to main¬stream risk reduction in development plans (Wamsler 2006). Hazard-related vulnerability should be addressed as an integral part of poverty reduction initiatives, given that the linkages between poverty, vulnerability and natural hazards are increasingly recognized (ODI 2005; UNISDR 2008). Practical ways to ensure that flood risk management is effectively incorporated into development plans are needed. Flood risk mitigation goals that should be considered in relation to mainstreaming are outlined below (adapted from ADPC 2010):

– Reduction of flood risk accumulated from previous urban development

– Avoid creating new urban flood risks in the future

– Build the capacity of all stakeholders – city governments, private sector, civil society and communities – to effectively respond to any type of emergencies.

Incentives for the integration of flood risk management include (ADPC 2010):

– Legislation for integrated flood risk management, including the integration of flood risk management into development plans, to provide an enabling environment in which integrated flood risk management strategies can be encouraged.

- Appropriate institutional arrangements for integrating flood risk management. The institutional structure should strengthen the horizontal and vertical integration of DRR between different levels of government and public administration, between other stakeholders, including the civil society, private sector, and universities, and between neighboring localities.
- Allocation of funds to city governments to support flood risk management institutions and their activities.
- Skills, capacities and tools need to be developed by government agencies for incorporating flood risk considerations in their day-today activities.
- Awareness-raising among government officials and the public to better understand the linkages between flood risk management, sustainable development and poverty reduction.
- Engaging with other stakeholders, including the local communities, in integrating flood risk management.

6.6.4.2. Oversight and enforcement of land use planning regulations

Much of the physical expansion and economic growth in the developing world takes place without following official plans, and outside official guidelines and regulations, in unplanned central city and peri-urban areas. To some extent, this is because large sections of the population cannot afford housing that meets official standards.

In addition, there is a mismatch between urbanization processes, urban governance, and decision making. The competence, capacity and accountability of local government structures often fall short of what is needed to adequately address urban growth and expansion (Satterthwaite et al. 2007). Enforcement of standards and regulations is often incomplete or even absent. Regulatory frameworks often demand unrealistic minimum standards while at the same time there is lack of adequate mechanisms for the enforcement of regulations.

Photo 6.4: Slum conditions in Brazil and Bulgaria, Source: Scott Wallace

Even when land use planning takes flood risk into consideration, the implementation and enforcement of guidelines and regulations often remains problematic. Potential constraining factors are outlined below (ADPC 2010):

- Lack of political will
- Lack of a legal frameworks with responsibilities clearly established
- Political influence of landowners and developers
- Public disregard for government policies and regulations
- Governmental disregard for policies and regulations established by other governmental levels or agencies
- Corruption
- Economic factors
- A perceived (or real) lack of viable alternatives

To overcome these constraints and facilitate the implementation of land use management, possible incentives and disincentives may include (ADPC 2010: 17):

- Offering land development subsidies in some areas and levy development overhead charges in others.
- Encouraging the location of industries and housing in safe areas by prioritizing in those areas the installation of utilities and urban services.
- Encouraging the use of certain areas through differential land pricing (in the case of undeveloped or underdeveloped land) or by subsidizing transportation from those areas to areas of employment, shops and businesses.

6.6.5. Financing operations and maintenance

Many municipal authorities do not have sufficient funds to meet their existing commitments, still less to meet additional responsibilities. Indeed, there is little incentive to do so, because there may be an expectation that flooding events will be funded by national government or external agencies.

Possible sources of financing for flood risk management measures were discussed in the previous section. The operation and maintenance of relevant infrastructures may however require additional finance from a local taxation base.

The raising of additional revenue, in many cases, may be problematic, and the retention of those funds for flood alleviation even more so. The charging of fees on insurance companies, which would benefit from lower claims, is likely to be inappropriate in developing countries because of the generally low level of cover and the requirement for national legislation. Additional local property fees could be levied, but these are likely to be ineffective in raising funds for the following reasons:

- Unrealistic level of rates
- Low yield
- Corruption
- Incapacity of the municipality to administer the system.

Case Study 6.10 which follows provides interesting insights into the incorporation of Disaster Risk Reduction (DRR) concerns into municipal budgeting.

Case Study 6.10: Integrating Disaster Risk Reduction in planning and budgeting in Palo in the Philippines

Some 12 of the 33 barangays (wards) in the city of Palo in the province of Leyte are flooded twice a year, experiencing from 0.3 to over 3 meters of floodwater. Floods adversely affect the living conditions and livelihoods of local communities as a result of deaths by drowning, and by exposure to water-borne diseases and drinking water problems. To reduce the impacts of flooding, the municipality initiated a review of their local planning and development tools to incorporate DRR.

Undertaken activities included participatory hazard, vulnerability and capacity assessments, in order to support the identification of appropriate flood risk management measures and the integration of these into the development planning and budgeting of the barangays, while aligning this with the systems of the overall municipal government. The assessment process identified the following challenges:

- Weak Barangay Disaster Coordinating Councils (BCCCs)
- Many houses were constructed using inadequate and flimsy materials and in hazard-prone locations
- Inadequate source of drinking water
- Absence of water-sealed latrines
- Eroded or unstable riverbanks
- Clogged waterways and drainage systems.

After the assessment process, the most appropriate measures and potential sources of funding were identified and responsibilities were allocated amongst the relevant administrative bodies. As an example of good practice, this case demonstrates the way in which DRR can be successfully incorporated into a municipality's Annual Investment Program (AIP). This included the provision of safe and potable water to households and the construction of school buildings that can be also used as evacuation centers.

Sources: DILG, GTZ. & DIPECHO 2008.

6.7. Preventing failure: effective monitoring systems and protocols

Monitoring of flood risk management programs needs to be twofold: firstly, the implementation of measures must be monitored and evaluated; secondly, and perhaps more importantly the fitness of purpose of the implemented system (i.e., its ability to reduce risk) must be monitored in the long term, as systems may not be regularly tested by actual flood events. The responsibility for carrying out a monitoring program is, ideally, delegated to the agency which is responsible for maintaining and operating the risk reduction solution. However, it may be appropriate for the requirements and design of the monitoring protocol to be enshrined in regulation or legislation. Either way, the system should be transparent and accountable if public funds are used in the development or maintenance of the measure.

Monitoring procedures and systems are needed to ensure that measures have the ability to perform to the required standards. Just as deterioration of levees can lead to early breaches (as they did in New Orleans in 2005), and drainage systems can become blocked (as they did in Mozambique in 2010), other measures and systems can also become prone to failure. This may be due to inattention to maintenance, to obsolescence, or to the departure of experienced individuals.

Different protocols and systems will be needed for each specific set of flood risk management methods but there are common threads which can be identified for categories of measures. As a first step it is necessary to analyze why a measure may fail and whether a monitoring procedure can be put in place to prevent this failure route.

Monitoring may also encompass the impact of flood defense on other systems such as ecosystems, or the livelihoods of local people, to determine whether remediation is necessary. This section focuses on the regular monitoring of implemented flood risk reduction measures.

6.7.1. Failure routes

It is instructive to examine why flood risk management solutions fail in the event of a flood. Evaluation of flood disasters in the past can help with this process, if this is carried out in a scientific and structured manner. Often, in the aftermath of a disaster, blame is attributed to a number of different sources: inevitably the authorities are blamed by the public, and frequently by the media, without the full picture being examined objectively. It is important to determine the underlying causes if useful lessons are to be learned, rather than to implement popular solutions in a 'knee jerk reaction' to media and public pressure.

6.7.1.1. Flooding which is outside the design standards

This is not really a failure of implemented measures, but may be perceived to be so by the public and the media. For example, the Japanese Tsunami disaster of 2011 saw overtopping of sea walls which was viewed as a failure. But, in reality, the structures had not 'failed' because they simply were not designed to withstand tsunamis of the scale of that event.

6.7.1.2. Failure due to unexpected consequences

Usually flood risk management solutions are unique in that, although the solutions are tried and tested elsewhere, the particular flooding scenario, topology and political and cultural environment are unique. There is also a need to design novel approaches for specific sets of circumstances; furthermore, new approaches may be developed which are seen to be more effective or efficient. This can result in unexpected consequences arising from a solution: an example would be the devastating environmental consequences of major flood control dam projects, which were not predicted in advance.

The US National Flood Insurance Program (NFIP) was set up in 1968 with the dual aim of protecting individuals from the financial consequences of flooding and directing development away from the floodplain. A recent evaluation concluded that while the scheme is partially successful in protecting against financial loss, it is far less successful in the second objective. The cause of this failure can be attributed to lack of awareness but also to 'moral hazard': the provision of insurance allows development in the floodplain to continue, and supports the reconstruction of previously flooded property, rather than encouraging resettlement. As a result, more homes are at risk of flooding than would be the case had the program succeeded in both of its aims. This failure can be seen to be behavioral with affected populations reacting to policy in an unanticipated fashion.

6.7.1.3. Failure due to structural deterioration

If structures are not monitored regularly they can deteriorate, and therefore fail in the event of a flood. Failure of levees in New Orleans was blamed on structural deterioration. Similarly, in Bangladesh the levees also sometimes fail for the same reason.

6.7.1.4. Failure due to lack of maintenance

This can range from failure to dredge channels to failure to check operation of floodgate mechanisms. For example, in Mozambique newly installed drainage channels failed to protect urban areas, due to the fact that they were blocked with debris: the emergency services were therefore forced to clear the drains through deep flood water.

6.7.1.5. Failure due to non-compliance

Floodplain regulations and building codes, evacuation and emergency plans can only succeed in their aims if people cooperate in complying with their stipulations. Often, due to complacency or self-interest people and organizations fail to comply and the solution fails in its protective aim. For example, in Venezuela the 1999 flood and debris flow killed an estimated 30,000 people, many of whom were living in slum developments in highly unsafe areas. Groundwater management programs have also failed to achieve their ends due to non-compliance.

6.7.2. Hard engineered defenses

The potential causes of failure of defense structure can be identified using a fault tree as illustrated in Figure 6.5 below in an example from the German Bight coastal area. Failure types and their probably of occurrence are evaluated. In this way the most likely failure route and underlying cause can be identified. Types of failure mechanism are also discussed in FLOODsite reports (2007; 2008).

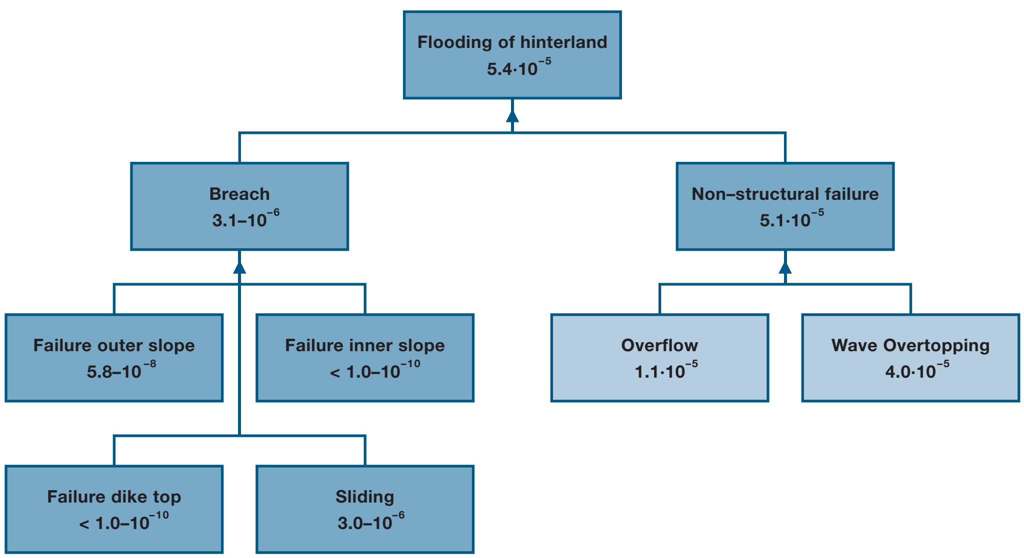

Figure 6.5: Failure tree for a dyke. Source: Adapted from Floodsite 2008

In this example failure caused by overflow and overtopping may be due to flows or levels exceeding the design standard. Regular updating of flood hazard maps should be used to establish whether the design standard is still appropriate.

Breaching (i.e. water passing through rather than over the defense) may also be caused by events exceeding the design capabilities of the system. However, the deterioration of the structure is another likely cause of breaches. Structural integrity can be periodically checked by visual inspection either on site or remotely, by the inclusion of sensor and structural tests, such as displacement sensors, water pressure sensors or periodical checks with an electromagnetic measurement system. Structural integrity testing is also required after any event has occurred. An appropriate monitoring schedule can extend the life of a hard defense by prompting remedial action.

The timetable of site inspections can be tailored to the flood type and frequency. Where there is a specific flood season, inspection can be carried out just prior to its commencement. If enough lead time is available then inspection can be carried out in anticipation of flooding, and any necessary emergency remedial work undertaken. However a program of regular inspections will allow for a smooth maintenance schedule and minimize the risk of failure.

Failure of operation is another potential route for failure of some types of defenses. Drills and tests of the mechanism should be carried out regularly. The use of a fault tree allows all failure routes to be considered and identifies which structures and elements of structures need checking.

Half of the Netherlands lies below sea level and is protected by over 15,000 levees, which are known as dikes or dykes. Failure of the levees could be catastrophic so the Dutch Water Boards employ levee patrollers in addition to laser and satellite scanning to monitor the stability of the levees and check for failures. The Dutch have also developed ways of reinforcing their dykes in difficult circumstances.

In the Netherlands during the heat wave of 2003 a dyke near Wilnis was breached due to the drying out of the peat, which is normally kept quite wet. During subsequent heat waves, such as that which occurred in July 2010, the monitoring program on the 3,500 kilometers of peat dykes is stepped up (RNW, 2010). Most levee patrollers have never seen a real levee failure as there is a relatively high turnover of staff (on average five years) and breakdown is rare. There is, therefore, a need for drills to educate the patrollers about the signs indicating imminent failure and the means of communicating that failure properly. The previously discussed game 'Levee Patroller' was designed to help with this training need, as discussed in Section 5.4.4.

6.7.3. Drainage systems

Some major causes of failure of drainage systems include deterioration of the structure leading to leaks; blocking of structures by waste, silt and debris; and demand exceeding the designed flow.

Deterioration of the structure can be monitored by regular inspections; this may need to be done remotely, via cameras, as many drainage systems are not readily inspected at surface level. Sensors and monitoring devices can also prove useful.

Blockage by waste, silt and debris can destroy the effectiveness of drainage infrastructure and can cause flooding in unexpected areas, often with contaminated floodwater. Regular clearance is necessary. Enlisting the help of the local population to alert the authorities to blocked systems can be invaluable. Local wardens or 'mile men' can be appointed to oversee a particular section of drainage.

Excess demand on drainage should be avoided via the use of planning systems which make new drainage a necessary part of construction. However, as this is not always possible, the demands on drainage due to urban expansion should be tracked to identify when remedial action is needed.

6.7.4. Forecasting and early warning systems

Forecasting and early warning can lead to flood emergency action and loss prevention, but relies on all elements to work together, as any weak link will result in partial or total failure. Therefore monitoring protocols are necessary for all elements. Failure of physical tracking system involving remote sensors, gauges or satellites can be made less likely by regular physical inspection. The data from these tracking systems is usually accessed regularly and so failure is likely to be picked up quickly. However, preventative inspection measures are also warranted, as even short term down time of the tracking system could cost lives in the event of a flood.

Software or model failure can be monitored regularly by checking the accuracy of forecasts against reality; continuous adjustment of models and model parameters to address any shortcomings in forecasts is required. Regular forecasts should be made in order to keep the system active.

Communication via hardware such as loudhailers, sirens and flags can be facilitated by regular physical testing of the equipment. Communications protocols can be tested via regular drills or desktop exercises. Failure to react due to desensitization of the population can become an issue, particularly if the incidence of false alarms is high. Attitude surveys can be used to assess the state of preparedness or apathy amongst populations at risk.

6.7.5. Emergency procedures

Emergency plans may fail because of problems with communications (as above), lack of clarity of roles and responsibilities, lack of trained personnel, outdated information or unforeseen difficulties with the planned actions. Simulations as described in Chapter 2 are a useful way to check the completeness and effectiveness of emergency plans. The lack of trained staff and high staff turnover issues both need to be addressed, via structured training for new employees, for example. Many emergency plans involve networks of individuals and organizations: a mechanism for notifying any changes of personnel, contact details and other important details should, therefore, be instituted.

6.7.6. Land use planning regulations

Land use planning and control regulations can fail for a number of reasons: illegal settlement; unauthorized building; building codes not adhered to; post-construction alteration of structures; and unauthorized changes of use. Tracking of settlement patterns and vulnerable assets (such as hospitals, schools, power infrastructure, and government control centers) should be an integral part of any flood risk management strategy. This information can also be used to assess the effectiveness of land use control programs. For example, in England and Wales, the Environment Agency reports regularly on any developments undertaken contrary to its planning advice, thereby providing a check on the effectiveness of the advice it gives (Environment Agency no date).

Similarly, a national indicator has been set up to monitor progress in delivering agreed actions towards flood and coastal risk management plans. Local authorities are scored based on percentage of these achieved.

6.7.7. Environmental monitoring

Flood defense systems may perform as expected in preventing flood risk but can have an impact on the environment over the long term, either positive or negative. Where such concerns exist, it is good practice to set in place a monitoring protocol which will track the environmental impacts and allow for remedial actions to be taken to prevent long-term damage.

6.8. Evaluation

6.8.1. Design of evaluations

The range of approaches and methods for evaluation of disaster relief or development interventions has grown considerably since the early 1990s. However, techniques specifically to evaluate disaster risk management programs, including flood risk, are somewhat less developed, and certainly less 'tried and tested'.

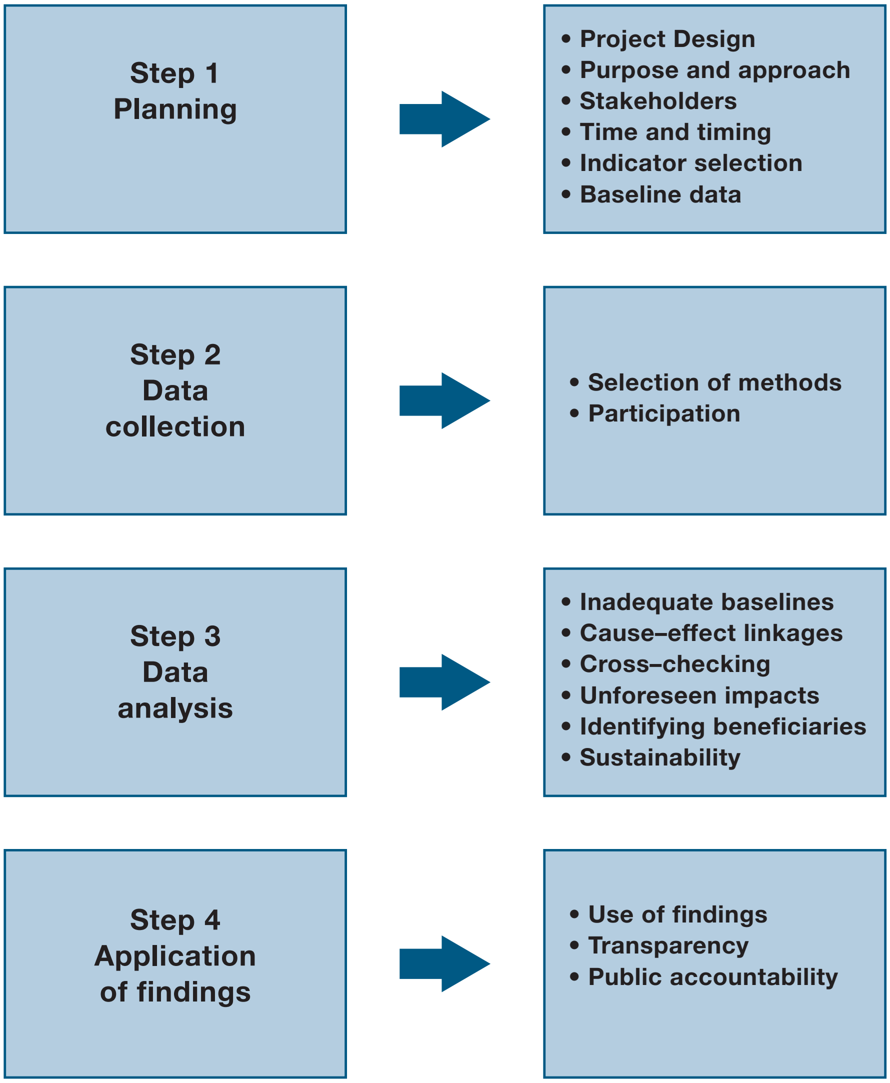

Figure 6.6: Steps in evaluating disaster risk management, Source: Adapted from Twigg 2007

There is a great diversity in possible purpose, approach and scope of evaluation. It is, therefore, necessary to make strategic (and often difficult) choices early in the process. It is important to determine why, and for whom, the evaluation is being carried out. This is schematically presented alongside/below (Figure 6.7) showing the range of stakeholders involved in even the simplest flood management intervention. Different stakeholder groups also need different types of information for different purposes. The evaluation aims and methods need to be specified for the particular disaster risk management project or program, including those directed at flood risk.

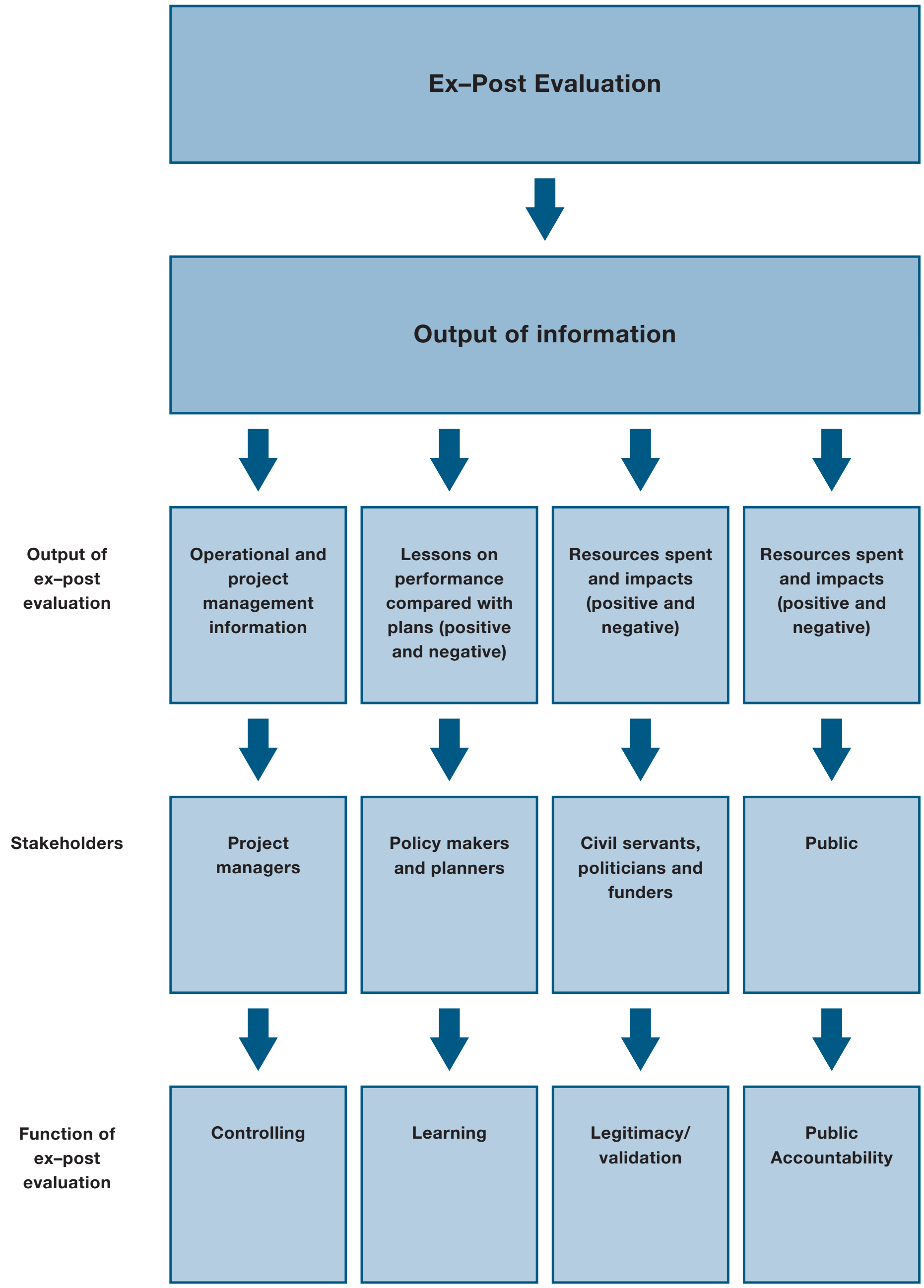

Figure 6.7: Ex post evaluation process. Source: Adapted from Olfert 2008

6.8.1.1. Clarifying the relevant dimensions of the evaluation

There are a number of dimensions to overall performance. It is important to determine which of these dimensions need to be evaluated, so as to ensure the output provides a comprehensive understanding of the overall performance of a solution, measure or instrument. The dimensions (sometimes termed criteria) can form the structure for reporting the evaluation findings. Examples are:

- Effectiveness - extent to which objectives are achieved
- Efficiency - in relation to costs
- Robustness or Sustainability - performance over time and under scope, scale and approach of the evaluation

The first step in planning an evaluation is to determine whether the object of the evaluation is a single 'stand-alone' intervention, or a wider portfolio of measures and instruments.

Usually, an evaluation covers all aspects of a project or program in order to capture the interactions and inter-relationships of different aspects of the intervention. However, evaluations can usefully be carried out for specific segments of a risk reduction intervention (an example is provided in Box 6.5).

Box 6.5 Evaluating Flood Forecasts

... access to information, reliability of forecasts and public trust are critical issues to be addressed when developing an advanced flood forecasting system.

Good transparent evidence of the forecasting effectiveness will greatly enhance public's willingness to respond. To maintain public confidence it is vital to evaluate the effectiveness of forecasts and warnings. This is very often missing, thereby undermining this important aspect of flood risk management.

Source: WMO/GWP (2005)

Some evaluations may assess a number of projects, perhaps each comprising several instruments. In these cases, clarifying the different conditions under which each project operates will be very important if findings are to be properly interpreted.

At a wider scale, an evaluation may assess disaster risk management structures, systems or organizations, as discussed in Benson and Twigg (2001). Alternatively, a risk management policy, or country strategy may be addressed, as described in (UNDP and UNISDR 2006).

6.8.1.2. Approach

Evaluations do not have to be formal, externally-led actions, such as those often required by donors after completion of a project. They can take many other forms, including real-time evaluations, after-action reviews with communities, strategic reviews and internal or self-evaluations by project staff and partners.

Where the evaluation process is led by the project in partnership with other stakeholders, there is stronger and more widespread ownership of the results; lessons can feed directly into the ongoing implementation or, where necessary, redesign of the project. The team chosen to carry out the evaluation should be selected on a range of factors: these include the balance between internal and external evaluators; the need for both technical and local knowledge; evaluation experience; relevant flood risk mitigation experience; and the gender balance within the team. Involvement of community representatives may be highly desirable; participatory processes, or beneficiary assessments, can complement or help validate information gathered through more formal or quantitative methods. Each approach should be selected according to its value in helping to understand the project's impact.

Good monitoring is an integral component of the evaluation system. It facilitates ongoing lesson learning by project managers, as well as provides data for subsequent evaluation. Traditionally, monitoring has been seen as relatively distinct from evaluation, but they are increasingly being treated as part of a single process directed towards lesson-learning and accountability (Wilkinson and Twigg 2009).

6.8.1.3. Time and timing

It is important that sufficient time is allocated to each stage of an evaluation – planning, design, mobilization and implementation; quality will almost certainly suffer if insufficient time is allowed.

Evaluations can take place at any point in the project cycle (for example, mid-term, end of project or post-project); however, the project should be sufficiently advanced to be able to assess effectiveness, at least at the level of outcomes. Retrospective, post-project evaluations provide a more comprehensive picture of impacts. Ideally, there should be a series of evaluation exercises during and after the project, to permit longitudinal analysis, but this rarely happens.

6.8.2. Measuring and analyzing impact

There are broadly three main approaches to impact assessment:

- Scientific approach, which generates quantitative measures of impact;
- Deductive or inductive approach, which makes use of anthropological and socio-economic methods;
- Participatory approach, which gathers the views of program stakeholders.

Participatory approaches are widely recognised as a key component in understanding impact, but have not been much used in the risk management sector to date. Depending on the approach, or combination of approaches being used, data may be collected through a number of methods as described by Wilkinson and Twigg (2009):

- Documentary evidence (for example, data records)
- Statistically valid formal surveys (for example, those affected by floods)
- Structured and semi-structured interviews
- Group discussions
- Rapid assessments (participative or otherwise)
- Direct observation
- Case studies
- Simulations.

Information and data is collected on the following:

Baseline state - the state before intervention

Target state - the state as was intended by the intervention

Observed state - the actually observed state

Indicators fall into two main types (although the terminology sometimes varies):

a. Those that relate to the implementation of programs (input, process and output indicators); and

b. Those which are concerned with the effects of programs (outcome and impact indicators).

Impact is often the most difficult to measure and attribute, this being further exacerbated by the dynamic and complex context of urban floods. The difficulty in specifying and measuring impact does not mean, however, that it is impossible; careful specification of impact indicators is an area where application and effort is required.

Process or output indicators, although usually easier to specify and measure, do not in themselves provide evidence that the intervention has had any impact. For example, the number of staff trained, or the regularity of water level measurements, would not necessarily result in flood risk mitigation. Output indicators may, in some circumstances, be used as proxies for impact but there needs to be strong evidence of causality between the action being measured and the related impact.

The selection of indicators is the most sensitive step in the evaluation process. Often they are established during design (in the project log frame, for example) to ensure that the expected outcomes or impacts are clearly specified. There is a web-based tool available to assist in this process (FLOODsite n.d.); the selection of appropriate indicators does, however, rely on clarity on the evaluation's purpose, the designer or evaluator's experience, and an in-depth knowledge of the intervention, project, program or portfolio in question.

6.8.3. Benefit-Cost Ratio

Benefit-cost ratio (BCR) is a commonly used economic efficiency indicator that captures the overall 'value for money' of a project or proposal. It is the ratio of the monetized benefits relative to costs, both usually expressed in current values or prices. It is also used as part of the cost-benefit analysis in the project planning process (as discussed in Chapter 5). The indicator measures how economically an outcome or impact has been generated.

A significant shortcoming of BCRs is that, although attempts may be made to monetize non-monetary impacts, often they are not accounted.

6.8.4. Gender and cultural aspects: the distribution of benefits

Benefits are unlikely to be evenly spread across a city, town or community. It is important to identify exactly who benefits from flood risk management initiatives, by assessing the socio-economic characteristics of beneficiary communities (disaggregated by gender and particular vulnerabilities, such as ethnicity, age and disability). There is plenty of guidance on incorporating gender and vulnerability into risk mitigation planning and design, and although less prolific, there is some specifically for evaluation for example, Benson and Twigg (2001); other gender-related references are listed at the end of this section.

Analysis of context is of particular importance for assessing the relevance and appropriateness of interventions. Evaluators should examine the extent to which the planning, design and implementation of interventions takes into account the local cultural milieu. A design which has clearly identified, in a participatory fashion, the differentiated risks and needs of citizens (women, men, girls and boys, or different social groups), is likely to result in appropriate outcomes and impacts for the various beneficiaries. Cultural appropriateness should also be considered: for example, an evaluation after the 1998 floods in Bangladesh found that shelters would have been more appropriate if they had been constructed with private space, including latrines, for women and girls, given the cultural seclusion norms (ALNAP 2006).

6.8.5. Providing evaluation feedback

An important outcome of any evaluation in this field must be to learn lessons and improve future project design and implementation. As a result, decisions on how the evaluation findings will be presented and disseminated are particularly important. This will depend upon the stakeholders for whom the evaluation was conducted: the output may take the form of a formal report and presentation to relevant officials, but if any aspect of public accountability is anticipated, then options such as public presentations, websites and public documents should also be considered.

6.8.6. Experience of evaluating flood risk measures

It is important that well-designed evaluations are carried out and the findings shared, so the sector can benefit. However, closer investigation shows that there have been relatively few coherent and comprehensive evaluations of disaster risk management concerning flood risk measures or projects, compared, say, to evaluations of disaster relief operations or development programs.

A study of 44 US state and territory post-disaster mitigation plans found that only 23 percent provided for evaluating success or failure (Godschalk et al. 1999). Similarly, a research project studied 22 international relief and development NGOs based in the UK, analyzing 75 mitigation and preparedness projects of different kinds. The researchers found that assessment or evaluation of impact had taken place in only 12 of the 75 projects (Twigg 2004). There is a general consensus amongst flood risk practitioners that real improvements in evaluation are required, in order that the utility and impact of flood risk management investment and initiatives is far better understood, and modifications are then made as necessary.

6.8.7. Further readings

6.8.7.1. Gender Aspects of Evaluations

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6.8.7.2. Guidelines for Evaluation of Relief Programs

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Boats travel through an urban landscape of flooding along the Borommaratchonnanee Road in the Taweewattana district in Bangkok, Thailand (2011). Source: Gideon Mendel

Chapter 7

Conclusion: Promoting Integrated Urban Flood Risk Management

Chapter 7. Conclusion: Promoting Integrated Urban Flood Risk Management

7.1. Introduction

Chapter Summary

This chapter summarizes the essential considerations for ensuring that flood protection is provided in an integrated fashion. It addresses the questions of how to initiate integrated flood risk management and how to calculate progress towards an effective integrated flood risk management framework. Evaluation and benchmarking are important steps in improving the design and implementation of flood risk management measures, both structural and non-structural.

The key messages from this chapter are:

- Flooding is having a major impact on millions of people every year and therefore flood risk management measures need to be implemented in the short term
- Impacts from flooding are growing and may become much worse in the future. Schemes must balance the short and long term and integrate structural and non-structural measures
- Successful long term implementation of flood risk management measures requires clear leadership, strong champions and the right institutional and legislative frameworks
- It is critically important to monitor and benchmark flood risk management even when there has not been a flood event for some time.

In the first six chapters of this guide the integrated urban flood risk management process has been described, from understanding the hazard and the risk, through to identifying appropriate measures, selecting these measures and implementing them. It has always been recognized that these measures will reduce but never entirely eliminate risk; similarly, the maximum potential protection may not be provided in the short term due to practical and resource considerations. Urban flood risk management then becomes an iterative process, with a long term target to be approached through a series of steps.

The chapter starts with 12 guiding principles for integrated urban flood risk management. The next Section 7.3 focuses on a five-step process to integrate flood risk management.

In the following Section 7.4, benchmarks are set out for the 12 principles of integrated flood risk management. These are designed to test progress towards the full integration of structural and non-structural measures, involving multiple stakeholders and within wider urban management in the longer term. This is helpful for discussions regarding the setting of future targets for the improvement of flood protection.

In Section 7.5 four detailed case studies of urban flood risk management illustrate how integrated flood risk management operates in a number of different city and town settings. Final remarks follow in Section 7.6.

7.2. Twelve key principles for integrated urban flood risk management

1. Every flood risk scenario is different: there is no flood management blueprint.

Understanding the type, source and probability of flooding, the exposed assets and their vulnerability are all essential if the appropriate urban flood risk management measures are to be identified. The suitability of measures to context and conditions is crucial: a flood barrier in the wrong place can make flooding worse by stopping rainfall from draining into the river or by pushing water to more vulnerable areas downstream, and early warning systems can only have limited impact on reducing the risk from flash flooding.

2. Designs for flood management must be able to cope with a changing and uncertain future.

The impact of urbanization on flood management is currently and will continue to be significant. But it will not be wholly predictable into the future. In addition, in the present day and into the longer term, even the best flood models and climate predictions result in a large measure of uncertainty. This is because the future climate is dependent on the actions of unpredictable humans on the climate – and because the climate is approaching scenarios never before seen. Flood risk managers need therefore to consider measures that are robust to uncertainty and to different flooding scenarios under conditions of climate change.

3. Rapid urbanization requires the integration of flood risk management into regular urban planning and governance.

Urban planning and management which integrates flood risk management is a key requirement, incorporating land use, shelter, infrastructure and services. The rapid expansion of urban built up areas also provides an opportunity to develop new settlements that incorporate integrated flood management from the outset. Adequate operations and maintenance of flood management assets is also an urban management issue.

4. An integrated strategy requires the use of both structural and non-structural measures and good metrics for "getting the balance right".

The two types of measure should not be thought of as distinct from each other. Rather, they are complementary. Each measure makes a contribution to flood risk reduction but the most effective strategies will usually combine several measures – which may be of both types. It is important to identify different ways to reduce risk in order to select those that best meet the desired objectives now – and in the future.

5. Heavily engineered structural measures can transfer risk upstream and downstream.

Well-designed structural measures can be highly effective when used appropriately. However, they characteristically reduce flood risk in one location while increasing it in another. Urban flood managers have to consider whether or not such measures are in the interests of the wider catchment area.

6. It is impossible to entirely eliminate the risk from flooding.

Hard-engineered measures are designed to defend to a pre-determined level. They may fail. Other non-structural measures are usually designed to minimize rather than prevent risk. There will always remain a residual risk which should be planned for. Measures should also be designed to fail gracefully rather than, if they do fail, causing more damage than would have occurred without the measure.

7. Many flood management measures have multiple co-benefits over and above their flood management role.

The linkages between flood management, urban design, planning and management, and climate change initiatives are beneficial. For example, the greening of urban spaces has amenity value, enhances biodiversity, protects against urban heat islands, and can provide fire breaks, urban food production and evacuation space. Improved waste management has health benefits as well as maintaining drainage system capacity and reducing flood risk.

8. It is important to consider the wider social and ecological consequences of flood management spending.

While costs and benefits can be defined in purely economic terms, decisions are rarely based on economic considerations alone. Some social and ecological consequences such as loss of community cohesion and biodiversity are not readily measureable in economic terms. Qualitative judgments on these broader issues must therefore be made by city managers, communities at risk, urban planners and flood risk professionals.

9. Clarity of responsibility for constructing and running flood risk programs is critical.

Integrated urban flood risk management is often set within and can fall between the dynamics and differing incentives of decision-making at national, regional, municipal and community levels. Empowerment and mutual ownership of the flood problem by relevant bodies and individuals will lead to positive actions to reduce risk.

10. Implementing flood risk management measures requires multi-stakeholder cooperation.

Effective engagement with the people at risk at all stages is a key success factor. Engagement increases compliance, generates increased capacity and reduces conflict. This needs to be combined with strong, decisive leadership and commitment from national and local government.

11. Continuous communication to raise awareness and reinforce preparedness is necessary.

Ongoing communication counters the tendency of people to forget about flood risk. Even a major disaster has a half-life of memory of less than two generations; and other more immediate threats often seem more urgent. Less severe events can be forgotten in less than three years.

12. Plan to recover quickly after flooding and use the recovery to build capacity.

As flood events will continue to devastate communities despite the best flood risk management practices, it is important to plan for a speedy recovery. This includes planning for the right human and financial resources to be available. The best recovery plans use the opportunity of reconstruction to build safer and stronger communities which have the capacity to withstand flooding better in the future.

7.3. The integrated urban flood risk management process

The figure 7.1 illustrates the process for integrated urban flood risk management. It overs all steps from understanding flood hazard and identifying the most appropriate measures, to planning, implementing and finally evaluating the strategy and its measures.

In this process three important issues should be highlighted. First, it is important to ensure that consultation is carried out for each stage of the process in a meaningful and effective way. Second, integrated urban flood risk management is a continuous process in which effectiveness will depend on how relevant stakeholders seek to raise awareness about flood risk and improve implementation of urban flood risk management. Third, failure to enforce and implement appropriate measures could increase the impact of flood events and undermine the resilience of a system.

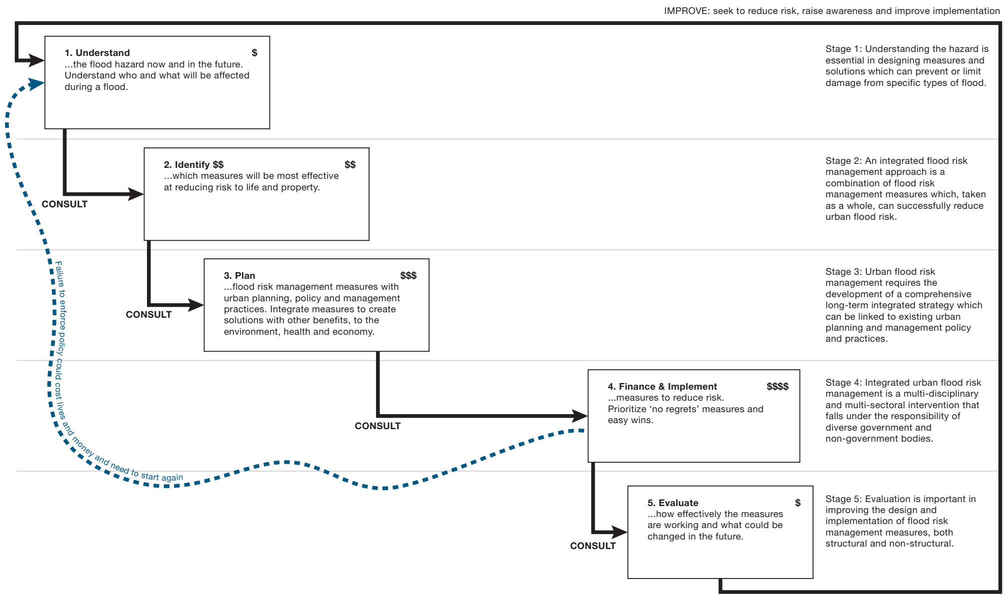

Figure 7.1: The integrated urban flood risk management process

7.4. Benchmarking progress

The concept of benchmarking can be useful to aid decision makers in assessing how well they are progressing with delivering integrated flood risk management. The following table sets out benchmarks in the development of better flood risk management, in alignment with the 12 underlying principles and the five stages of delivery. The user can review the work that has been done in a particular urban area or country, identify from the table, broadly speaking, how far they have met the principles at that stage, and thereby establish what is required to advance towards a more integrated solution. Case studies in the guide which illustrate the principles are listed.

Table 7.1: Benchmarking progress.

Principle	Case studies	Understand	
Every flood risk scenario is different: there is no flood management blueprint.	Spatial analysis of natural hazards and climate variability risks in the peri-urban areas of Dakar A megacity in a changing climate - Kolkata	Understand the multiple sources of hazard and risk	
Designs for flood management must be able to cope with a changing and uncertain future.	Flexible planning: Thames Estuary 2100, UK Integrated Flood Management Strategy for Ho Chi Minh City (HCMC), Vietnam	Consider climate change and urbanization and look for other uncertainties	
Rapid urbanization requires integration of FRM into regular urban planning and governance.	Integrating Disaster Risk Reduction in planning and budgeting in Palo in the Philippines	Understand the diversity of flood management roles and urban conditions	
An integrated strategy requires the use of both structural and non-structural measures and good metrics for "getting the balance right".	Flood management in Jakarta, Indonesia Vaisigano Catchment Cost Benefit Analysis: Samoa	Understand the benefits and limitations of different approaches	
Heavily engineered structural measures can transfer risk upstream and downstream. It is impossible to entirely eliminate the risk from flooding	The Mississippi River Floods of 2011 - Morganza Floodway Modernization of the Wroclaw floodway system Camanava anti-flood project 2003-2011, the Philippines	Consider the wider catchment and whether the measures will make it worse elsewhere Understand that rare extreme events, outside the observed record will occur	
Many flood management measures have multiple co-benefits over and above their flood management role.	Solid waste disposal in Bamako, Mali Kuala Lumpur SMART Tunnel, Malaysia New York City Green Infrastructure Program	Understand how flood risk fits within broader natural hazards and urban development concerns	

Identify	Plan	Implement	Evaluate
Consider range of alternatives appropriate for specific risks	Look at existing structures, measures and plans	Tailor implementation to fit in with local customs and preference	Recognise the relative risk reduction rather than absolute risk levels
Carry out sensitivity testing and choose robust alternatives	Identify under what circumstances plans would need to change	Build in maximum flexibility to built structures, systems and policies	Test robustness to future scenarios and plan regular revisions to coincide with new forecasts
Look for synergies with existing roles and other development goals	Consult widely and engage in joint planning	Coordinate implementation to maximize efficiency and demonstrate benefits	Agreed targets can be monitored as part of regular monitoring programmes
Consider both types of measures and mixtures of the two	Ensure that all required elements are planned for and particularly that capital investment is backed up by the right forecasting and warning regime	Implement the most cost effective measures first and often makes sense to put the non-structural elements in place first	Evaluate as a scheme but identify where failures are most likely
Identify measures which transfer least risk, look for ways to deal with any flows conveyed elsewhere	Consult widely and set up compensation schemes or mitigation actions in areas at increased risk	Communicate changes in risk and implement schemes to offset risk in other areas	Monitor the effectiveness of compensation and awareness of changing risks
Choose measures which will not cause more harm if they are overtopped or fail	Determine the appropriate level of protection and plan for what will happen when it is exceeded	Set up warning and evacuation systems for the residual risk	Always measure against planned levels of protection rather than zero risk
Identify measures which have the potential to contribute other goals	Consult widely and engage in joint planning and target setting	Consider co-financing and involve all stakeholders during implementation	Measure against wider goals but specifically identify the impact on flood risk

Table 7.1: Benchmarking progress continued.

Principle	Case studies	Understand	
It is important to consider the wider social and ecological consequences of flood management spending.	The Dilemma of Poverty and Safety: The Case of Urban Flooding in the Aboabo River Basin in Kumasi, Ghana Surat Vulnerability Analysis, India Cost-Benefit Analysis for Community-Based Disaster Risk Reduction in Nepal	Undertake vulnerability analysis in the broadest possible sense	
Clarity of responsibility for constructing and running flood risk programs is critical.	Flood preparedness and emergency management programs in Cambodia	Identify communities at direct risk but also those indirectly affected. Map the organizations agencies and governance structures surrounding these communities.	
Implementing flood risk management measures requires multi-stakeholder cooperation.	Flood and Typhoon Resilient Housing in Vietnam Flood risk management and children's participation in Mozambique Chengdu urban revitalization Multi-stakeholder collaboration for better Flood Risk Management in Metro Manila, the Philippines	Use participatory risk and vulnerability assessment procedures alongside the best available scientific predictions	
Continuous communication to raise awareness and reinforce preparedness is necessary.	Raising awareness of disaster risk through radio drama in Afghanistan Multi-stakeholder flood management in Malawi	Share hazard and risk maps with the public in the most accessible way possible	
Plan to recover quickly after flooding and use the recovery to build capacity.	The case of the tsunami-damaged village of Xaafuun, Somalia	The residual risk should be measured	

	Identify	Plan	Implement	Evaluate
	Consider all impacts of proposed measures e.g. via environmental and social impact assessment	Use MCA to select measures and engage and consult with affected stakeholders throughout the planning process	Continue to engage stakeholders, take mitigating actions and ensure grievance and compensation procedures are in place	Track and monitor potential impacts identified in earlier assessments. Use participatory approaches
	Identify measures that can be either controlled or influenced by the agencies and government bodies involved in the decision	Engage all stakeholders in decision making but clearly define roles and responsibilities	Assign responsibilities for implementation as well as for running and maintaining systems. Enshrine in legislation, redefine departmental roles or set up new structures if necessary	Involve all stakeholders including hard to reach groups and those who were involved in the planning stages
	Consult widely including the use of local networks to reach vulnerable people. Assess capabilities of available experts, peer knowledge networks, local businesses, and NGOs.	Put in place agreements for support and mutual cooperation amongst stakeholders	Engage the maximum number of stakeholders during implementation to cement relationships	Ensure stakeholders' goals are addressed in the evaluation
	Consult on different options setting out clearly the costs, benefits and consequences,and respond to feedback	Detailed plans should also be shared and consulted on.	Many measures require detailed communication of expected behavior or compliance procedures. Communication should be wider including the limitations of measures and the need to maintain vigilance.	Two way communication of the success of measures, particularly damage avoided and the need for more and better FRM is needed in the long term.
	Ways of dealing with residual risk usually include emergency planning warning systems insurance etc	Plan to fail gracefully and put in place emergency procedures. Ensure that disaster management infrastructure is situated in the lowest possible risk area	Prioritise critical infrastructure and vulnerable people. Take the opportunity to build in resilience	Check that the recovery has increased the resilience to future events

7.5. City case studies: integrated urban flood risk management

7.5.1. Argentina: Urban Flood Prevention and Drainage Program

Over 80 percent of Argentina's population and economic activity is located in the alluvial flood plain of the Parana and La Plata Rivers; in areas subject to flash floods, near rivers draining the foothill of the Andes; and in flood-prone urban river basins. As a consequence of such vulnerabilities, the country has suffered widespread floods in 1983, 1985, 1992 and 1998, causing direct damage in excess of US$1 billion each year. Cities are particularly at risk due to the uncontrolled urbanization of flood plains, insufficient drainage infrastructure, decimated storm water storage systems, and weak institutional and policy frameworks.

Since the early 1990s, reducing flood-related risks became a top priority of the National Government which has led and financed strategic programs to reduce vulnerability to flood hazards countrywide. These programs are being implemented in close coordination with provincial governments, the City of Buenos Aires, and local authorities; and with participation of international institutions like the World Bank and the Inter-American Development Bank. The strategic approach started from initial emergency response programs targeting the rehabilitation of damaged infrastructure, disaster response programs and institutional coordination. Flood prevention programs followed; encompassing structural and non-structural measures to protect lives, defend infrastructure and reduce loss of economic output. A third phase includes support to enhance the capacity of drainage infrastructure, further improvements of land use planning and integrated water management, among other policy and institutional interventions, to increase the level of flood protection in urban centers and in selected rural areas.

In the case of the city of Buenos Aires, a basic drainage system was built in the 1930s. However, existing drainage infrastructure is not capable of handling the combination of intense storms with less than 10 years of frequency period, distributed over almost 100% land imperviousness, and deficiencies of the solid waste collection system of a city with average population densities of about 150 inhabitants per hectare—reaching 300 in some part of the city. Weather variability is also a factor because there is evidence of more intense storms originating on the southern Atlantic system, which are frequently combined with higher sea surge events. The combination of these factors—urbanization, imperviousness, high groundwater table, and climate variability—makes drainage a very complex issue for the entire city of Buenos Aires.

To address these issues, the Government of the City of Buenos Aires requested the financial assistance of the National Government to undertake a comprehensive urban drainage master plan. It was finished in 2004 by a consortium of international and local consulting companies, under World Bank financing. The master plan allowed for a better understanding of flood issues in Buenos Aires, and for a sound evaluation of flood management options within an integrated approach encompassing structural and non-structural measures, sound socioeconomic analysis, and environmental impact assessments. In 2007, a flood management and investment project was approved for the Maldonado river basin, which received the highest priority because it is the most affected urban basin of the city. By the end of 2011, large underground tunnels are almost completed, a network of secondary drainage conduits is under construction, and non-structural measures are underway; including installation of rain and gauging stations, operation of sophisticated drainage models, and studies to improve land use management and solid waste collection. A follow up program is envisaged to other urban basins and consolidate ongoing non-structural efforts.

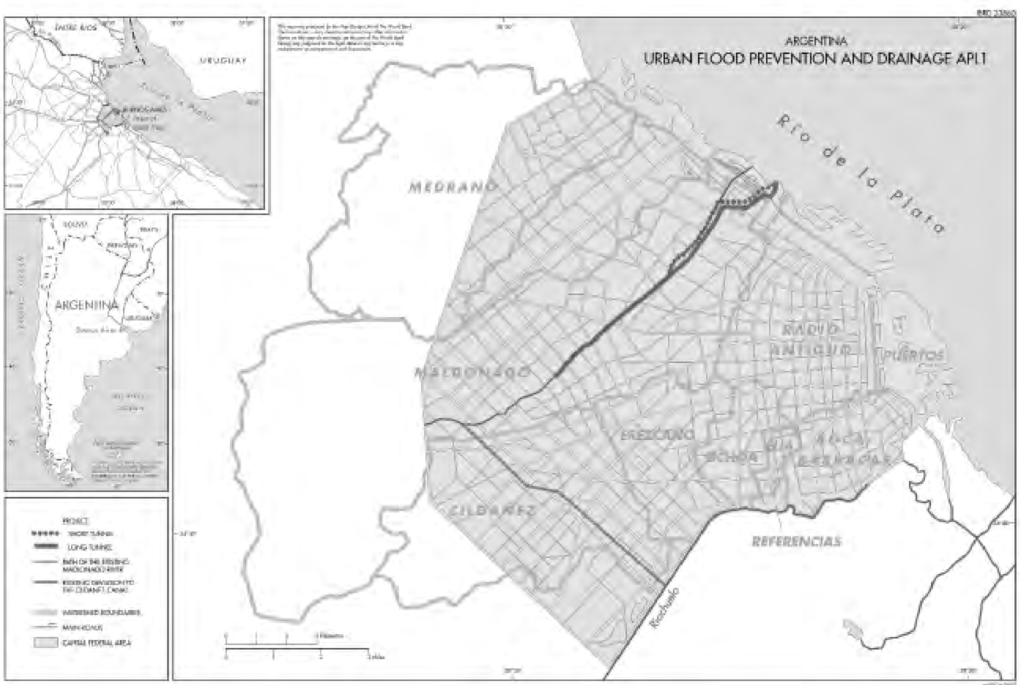

Figure 7.2: Buenos Aires drainage master plan, Source: World Bank (2005)

The next sections describe the two phases of the program currently underway for both Buenos Aires and for selected provinces. These phases aimed at protecting valuable economic assets and persons living in flood-prone areas by constructing physical defenses, by implementing a housing program to increase the resilience of lowest-income population, and by strengthening national and provincial institutions and systems for dealing with flooding.

Phase 1

The proposed measures intended to reduce Buenos Aires's exposure to flooding through the improvement of the level of protection provided by its drainage system and the implementation of a risk management program. The project focused on the issues of risk identification and reduction through prevention, mitigation, and education.

To achieve this, the project aimed at increasing the city's resilience to flooding through: (a) land use planning, building codes, construction practices, urban environment management, increasing information through hazard maps, contingency plans and vulnerability analysis; and (b) the improvement of the city's flood defenses through water drainage. The project has three main components as described below:

Component 1: Risk management scheme

This component has funded actions aimed at providing assistance to the city government to promote a risk management approach in dealing with floods, including prevention, mitigation and response. In addition, the component would strengthen the existing administrative bodies so that the transfer of responsibilities from the implementation unit to the agencies would be planned during project implementation.

Component 2: Development of key defense facilities

The structural measures component funds works for a total of US$ 282 million, including the construction of two collection tunnels of respectively 9.9 km and 4.7 km (US$ 192 million), and 46 km of additional secondary connections (US$ 90 million) to improve the functioning of the existing draining system in the Maldonado Basin. The tunnels were designed to complement existing underground systems to increase peak flow discharge capacity for the entire basin. Main underground tunnels are expected to be finalized by mid-2012. However, a large part of the secondary network should have to be completed in a follow-up phase.

This component also includes:

- Development of detailed project feasibility studies for the other water basins of the city to assist decision making for future drainage infrastructure investments aligned with the Master Plan
- The component included contracting a specialized team to supervise tunnel construction, as well as a Technical Panel of Independent Advisors to review the strategic approach of the project and assist with engineering design

Implementing non-structural measures is lagging behind, but there are already a few important outcomes like the Hydraulic Interpretation Centre, launched in October 2009, which is open for public consultation.

Component 3: Project Implementation and Auditing

The existing project implementation unit, under the administration of the city, would progressively transfer the operation of hydraulic assets and non-structural programs to permanent agencies based on their institutional capacity, complemented by training programs.

Phase 2

Phase 2 targets six provinces, and it aims at strengthening the country's risk management capacity by supporting institutional development and flood management infrastructure investments. This phase was prepared within the framework of the Federal Water Agreement under the leadership of the provinces and in close coordination with inter-jurisdictional Federal Hydraulic Committee (COHIFE). COHIFE was responsible for developing nationwide water management principles that has been adopted by provincial governments and they are the basis for coordinated action. Within the COHIFE framework, the most flood prone provinces were selected. This phase focuses on:

- Institutional strengthening by providing flood risk reduction instruments to the provincial institutions
- Improving flood preparedness for vulnerable areas not benefited from structural defenses. This provided improved housing in safe areas for lower income families living in flood prone areas and for those that were resettled from for the works
- Developing key defense structures to protect important urban areas against flood effects.

Lessons learned from past operations in the country

- Investments are affected by unpredictable allocations of public funds to infrastructure investment programs, which are subject to modifications that delay progress of project implementation
- Flood protection projects in Argentina are designed with limited consideration to financing recurrent costs and the institutional support to maintain assets which hare built. To address this issue, the City of Buenos Aires has contracted the maintenance of existing drainage works to the private sector, and committed itself to extend the contract for the newly built network and to prepare a separate maintenance contract for the tunnels due to their technical specificity
- Inadequate collection of solid waste compromises the performance of drainage systems. Unfortunately, effective solutions to this problem are still challenging
- The existing coordination procedures, across government jurisdictions, were agreed in a context of weak provincial institutional capacity—they should be updated to improve efficiency and effectiveness.

Policy lessons

- Water basin strategies have helped prioritize interventions in the rural and urban areas.
- The non-structural measures added to the protection effects of the physical interventions at the city level are essential to build resiliency to floods
- Flood protection projects are designed and implemented with limited consideration to maintenance. Experience has shown the importance of including comprehensive maintenance strategies to sustain the overall condition of the infrastructure
- Lengthy procurement procedures and the timing of local elections explain most of the slow progress of some components of the program. In Buenos Aires, once the main contracts were awarded, works have proceeded as planned.

Sources: World Bank 2005; World Bank, 2006; Halcrow, 2011. Buenos Aires drainage master plan: http://www.halcrow.com/Our-projects/Project-details/Buenos-Aires-drainage-masterplan/.

7.5.2. Germany: Cologne flood prevention

Cologne, with a population of one million, is the fourth largest city in Germany. Flooding is not something new in the city, as flood events have been reported from as far back as in 792 CE.

The Group of Municipal Drainage Operations Cologne (Stadtentwässerungsbetriebe Köln or StEB) is a municipal corporation responsible for the city's water management activities, including sewage disposal and drainage, flood control and prevention, and management of surface waters.

With regard to flood protection, StEB provides protection against 100 and 200 year flood levels along 67 kilometers of the banks of the River Rhine. In addition to structural flood protection such as retention areas, StEB provides floodwater management and ensures that the population is well informed about flood risk management activities in their area. More details with regards to flood risk management in Cologne are presented below.

Structural and mobile flood protection

Work carried out along 67 kilometers of the Rhine's banks enabled protection levels to be raised to that appropriate to a 1:100-year event, for the most part, and to a 1:200-year event in particularly critical areas. In addition, two retention areas were created for receiving and holding back the river water. The total cost for these measures was about US$ 600 million. Given that a flood level of a 100-year event would affect more than 150,000 inhabitants, the investment is considered as both effective and efficient.

For the structural measures, StEB sought a design concept that would be compatible with the city's appearance. For this reason, StEB conducted individual architectural competitions for the new flood pumping stations, and furthermore, Cologne's design advisory council, as well as individual citizens, took an active part in designing many flood protection installations. This aspect was also important to ensure that the new structures would be accepted among the citizens.

Photo 7.1: Pumping station in Cologne. Source: Peter Jost, pj-photography.de

A fundamental element of Cologne's new flood protection system is the 'mobile walls' (also termed demountable defenses) which, if necessary, can be deployed in less than 10 hours along a total length of 9.5 kilometers of riverbank within the city area. In total, 350 people drawn from StEB, THW (Germany's technical relief organization) and contractors are available for the loading, transportation and erection of the walls.

Figure 7.3: Raising and enhancing the existing flood protection with mobile walls. Source: Heinz Brandenburg, StEB

Flood management and risk prevention

Structural measures, including drainage systems, flood protection walls and dykes, together with the construction of bridges for flooded settlements, are important components of the city's flood protection strategy. These are complemented by measures improving both flood prevention and management of flood hazards. These approaches include management of traffic, setting up ferry services for flooded areas, and the provision of pumping deployments.

A flood protection center has also been formed to ensure that these management tasks can be achieved quickly and efficiently. The centre's activity is triggered whenever the Rhine reaches a level of 4.50 meters at the Cologne water gauge (KP). Citizens and others involved with flooding are kept informed of developments and of countermeasures both taken and yet to be taken, once levels reach this height. This is done via internet or telephone. In addition, a citizen's hotline is set up to answer questions directly.

If the river reaches a height of 7.5 meters, the Major Centre for Flood Protection, which includes all authorities, services and other relevant institutions, will take action. The Centre is responsible for coordinating and reconciling all measures between the involved agencies.

A constant flow of information and coordination of protection measures is essential for the Centre to perform its work. FLIWAS, the 'FLood Information and WArning System' which was first tested during a flood protection drill in 2009, enables the collection of all information relevant to a flood emergency. In its basic version, FLIWAS monitors water levels, communications, organizational, operational, and evaluation plans as well as providing testing and training.

To enable individuals to determine whether their property or residential area could be affected by flooding, risk maps are available on the internet. These maps show flood levels and how floods could spread in the affected area, including a comparison of developments with and without flood protection facilities. To make sure emergency personnel are well prepared, regular flood emergency drills take place. In addition, StEB conducts campaigns to raise the population's awareness to flood hazards and impacts, and also involves citizens through consultation with regards to structural measures.

Policy lessons

- StEB's approach considers the entire water cycle in all of their activities.
- The overall strategy is not focused on short-term targets but considers quality, overall economic viability and ecological sustainability.
- Response to flood risk is not focused only on structural protection measures but includes non-structural flood management and prevention activities.
- Policy makers were convinced of the necessity of implementing these flood protection measures only after the catastrophic flood events in 1993 and 1995 had caused damages of more than US$ 120 million.
- Information availability, such as the development of risk maps, is an issue which StEB prioritizes.

To most effectively manage all these activities, StEB carries out research and analysis of future challenges, including the possible impacts of climate change and the consequences of urban demographic shifts.

Sources: Brandenburg 2011. StEB nd.

7.5.3. Mozambique: Integrated flood management in Mozambique's cities and towns

Mozambique is located on the confluence of many major Southern African rivers including the Zambezi River and the Limpopo River. The country has been hit by 34 significant cyclones and four major flood events in 2000, 2001, 2007 and 2008.

Maputo, the capital of Mozambique, houses 45 percent of the total Mozambican urban population, 36 percent of which is considered to live below the poverty line. Recent data indicate increasing rural-urban migration, contributing to higher poverty and vulnerability levels. Throughout Mozambique, both urban and rural areas are at risk from flooding. However during the 2000 floods 70 percent of the lives lost were recorded in urban areas near to Maputo, mainly in the cities of Xai-Xai and Chokwe.

The Cahora Bassa Dam, together with the Kariba Dam in Zimbabwe, serves several Southern African nations as a dual purpose system which generates electricity and also helps to control river flow. Previous regular flooding of the river basin was much reduced by the controlling of the output from the dams. Although these dams are not primarily flood control mechanisms, their impacts on river flow clearly affects flood frequency and severity. Nevertheless, heavy rainfall in the region often raises the water level in the rivers thus increasing flood risk. In addition, many cities on or close to the Indian Ocean, including Maputo, are particularly vulnerable to sea level rise.

Flood risk mitigation efforts in Mozambique, and in Maputo in particular, involve multiple initiatives, with the majority of these being non-structural measures. A Disaster Risk Reduction (DRR) strategy which incorporates climate change concerns has been in place since 2003.

The National Institute of Disaster Management (INGC) is a government entity responsible for disaster prevention, response, and recovery. The institute is guided by a medium and long term 'Master Plan for Prevention and Mitigation of Disasters', which focuses on vulnerability reduction and strengthening the disaster preparedness of people living in areas highly exposed to natural hazards. Awareness-raising tools were introduced to local communities, through schools and government organizations, aimed at enhancing people's capacity to cope with flooding. In addition, field-testing activities for the implemented measures take place through the training of Local Disaster Management Committees, as well as simulation exercises.

Flood preparedness is also facilitated by an early warning system, coordinated by the National Directorate of Water, together with the National Institute of Meteorology and the National Disaster Management Institute. The system provides forecasts of flood risk; detects and monitors flooding; and issues flood warnings when necessary, paving the way for a coordinated response.

In 2003, UN-HABITAT produced a manual based on the concept of 'living with floods', and presented issues around water using simple and realistic ways: for example, showing simple adaptation measures for buildings and introducing a cards game (as illustrated in Figure 7.4). These recommendations were derived from real situations, easily recognizable by the local communities.

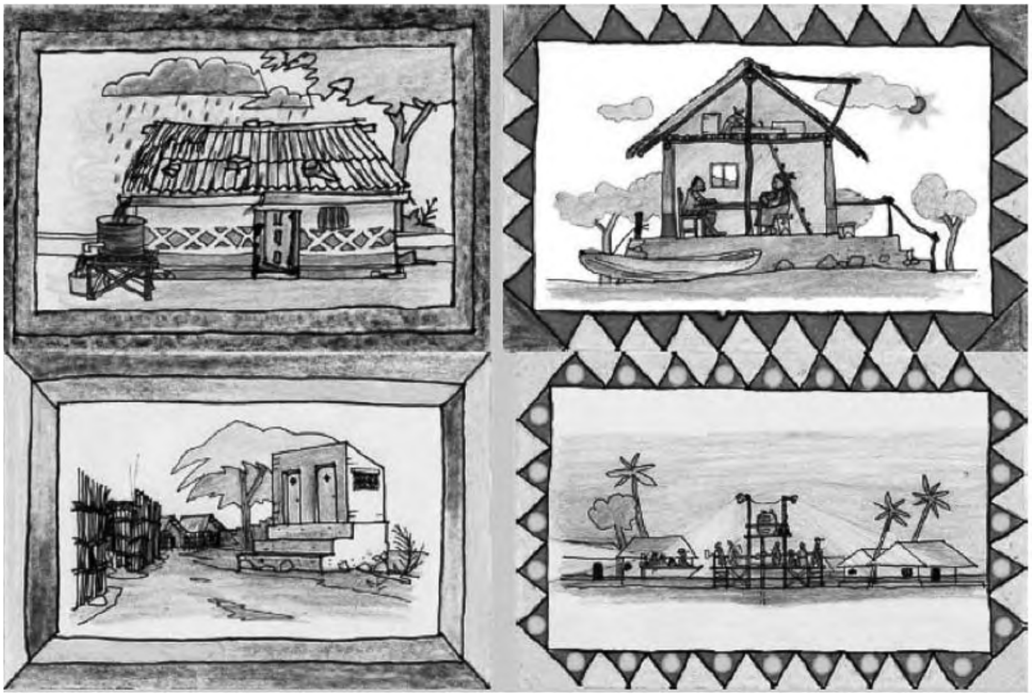

Figure 7.4: Examples from manual on ‘living with floods’ - rainwater harvesting, ideal house, elevated latrine, and supporting platform for temporary evacuation and protection of goods. Source: UN-HABITAT.

Other measures included the construction of flood resilient buildings: one example is in Ihangoma, a village located at the confluence of Zambezi and Shire Rivers, which experiences frequent flooding. The building serves as temporary refuge during floods but is otherwise used as a school or for other community services.

During the 2000 and 2001 flood events, despite the fact that some affected areas had land use plans, including measures to mitigate against erosion and landslides, these were often not followed or enforced. Insecurity of land and shelter tenure was also a major issue for flood-affected communities. GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) reported that some people refused to leave low-lying land, despite efforts to move them to safer locations. In response to this the United Nations Environment Program (UNEP), UN-HABITAT and the Government of Mozambique developed a project aimed at improving the security of land tenure in flood affected areas. This was approached through:

- Providing the necessary equipment for institutions to deal with land registration
- Improving the technical capabilities of relevant authorities to prepare maps of urban settlements affected by the floods

– Reviewing the legal and institutional framework with regards to land rights.

Urban drainage projects have also been carried out, including the construction of urban drainage channels, for example in the Mafalala district of Maputo and at the border of the Mafalala and Urbanização districts.

Photo 7.2: Drainage in Maputo Bairro Urbanização, Well-functioning drainage is very important for preventing that sanitary systems overflow during heavy rainfalls. Source Sustainable sanitation/Åse Johannessen

In 2010, however, despite the improved drainage system solid waste caused blockages resulting in flash flooding and necessitating emergency clearance of the drainage channels This happened despite the fact that the government implemented an improved citywide solid waste management system, financed by a ‘garbage tax’ levied upon electricity bills.

Policy lessons

– Following the Mozambique flood in 2000, the World Bank highlighted that consultation had improved the nature of the interventions, but participation leading to empowerment was rare

– Awareness-raising tools were introduced to local communities in order to enhance people’s coping capacity. These tools were derived from real situations, easily recognizable by the local communities

- Construction of flood resilient buildings which can serve as temporary refuges during flooding, but otherwise used for other community services, is an innovative and cost-effective response to flood hazard risk

- Floods may expose problems of poor land management prior to a disaster.

Sources: ALNAP and Provention 2008; ADPC 2006 ; UN-HABITAT 2007; OCHA 2001; Hellmuth et al. 2007; Kruks-Wisner 2006; Magaia 2011; UNDP and ECHO 2010; UN-HABITAT n.d.

7.5.4. Indonesia: Flood management in Jakarta

Greater Jakarta is the political and economic centre of Indonesia. It has an estimated population of about 28 million and accounts for a quarter of the Indonesia's non-oil GDP. Jakarta is located in a flat low-lying fan-shaped region intersected by thirteen rivers originating from the mountains to the south. Around 40 percent of the city is between one to one and a half meters below sea-level. Every year, large parts of the city are flooded during the rainy season.

Floods were especially severe in February 2002 and February 2007. During the latter event, 36% percent of Jakarta was inundated with floods up to seven meters deep, causing over 70 deaths and displacing 340,000 people. In November 2007 rising sea tides created "little tsunamis" with gushing water inundating hundreds of houses in the low-lying neighborhoods in the northern part of the city. The floods in 2008 caused 30 deaths and shut down Jakarta's international airport for three days. Floods have caused severe disruption in the city: BAPPENAS, Indonesia's National Development Planning Agency, estimated the financial losses from the 2007 flood at US$900 million. However, the total socio-economic losses are significantly higher, and include loss of human life, health costs, labor and school days lost.

In the past few years, significant efforts towards flood mitigation have been undertaken which has resulted in a system of canals and polders (low lying areas that act as temporary storage) which discharge into the sea. In the future, it is expected that sea level rise, land subsidence and storm surges, due to unpredictable weather patterns, will cause even more disruption.

History of flood control measures

Previous flood control measures were installed to protect the main city areas to a design level of a 1:100 year flood. This resulted in the construction of two major floodways: the Western Floodway and Eastern Floodway. These channels were designed to intercept flood flows from all rivers before they entered lowland areas (the city area as it was at that time) and to convey the water directly to the sea. There are also sea walls protecting Jakarta from flooding from the sea.

The Western Floodway was planned as an extension of a previous floodway (constructed in 1924), which intercepted the Ciliwung, Cideng and Krukut rivers. The extension was designed to cope with the Grogol, Sekretaris and Angke rivers as well. It was completed in 1992 at a cost of around US$ 100 million mainly financed by Japan's ODA.

The objectives of the West Jakarta Flood Control System Project were:

- To construct the Sarinah/Thamrin Drainage Pumping Station and the Grogol/Sekretaris Interceptor in order to better control floodwaters in the west Jakarta region.
- Construction of the Cengkareng Floodway (non-ODA loan project).
- Repairs to Melati Regulating Pondage, Cideng Thamrin Waterway, and Krukut Waterway.
- Improvement of outlet works for Pluit Regulating Pondage.

Embankment improvement works were also added to the construction of the Sarinah/Thamrin Pumping Station, and this helped to improve the capacity of the drainage network for this region

The Eastern Floodway was designed to intercept all other remaining rivers (Cipinang, Sunter, Buaran, Jatikramat and Cakung) and to discharge to the Java Ocean. Conceived originally in 1973, the project commenced in 2002.

The objectives of the East Flood Canal Project were to:

- Excavate and construct a 23.57 kilometer canal, running from Cipinang in East Jakarta to Marunda in North Jakarta, discharging into the Java Ocean.
- The canal measures an average of 100 meters to 300 meters in width and 3.7 meters in depth.
- Canal flow capacity was designed to be 390 cubic meters per second.

The project was funded by the Jakarta administration and central government and has progressed very slowly due to the complicated process of land acquisitions. The project finally reached the sea on December 31, 2009, but there are still unfinished works in several spots. In the aftermath of the 2010 flood, the government planned to connect the Ciliwung River to Cipinang River (which is now intercepted by the East Flood Canal) to provide connection between the East and West Flood Canals.

The floodways were planned to contain 1:100-year floods (290–525 cubic meters per second) for the Western Floodway and 101–340 cubic meters per second for the Eastern Floodway. Areas located downstream of the two floodways were divided into six drainage zones covering about 240 square kilometers. Most of the land (about 150 square kilometers) with an elevation of less than two meters is considered as polder; the rest is treated as gravity drainage areas, with pumps and reservoirs releasing flood water from the polders. The existing old river channels were considered as primary drainage, and only designed to contain 1:25-year floods.

Evaluation of measures

The floodways have been judged to be partly effective in preventing flooding in Jakarta. According to records there were six major floods in the ten years prior to the construction of the Western floodway. However, in the ten years that followed the completion of the project in 1992 there were only two major floods, one in January and one in February of 1996. During this period there were no particular changes to weather patterns for Jakarta and the regions upstream, and there were still periods of very heavy rains in which more than 100 millimeters of precipitation fell in one day. Further, no other flood control projects were being conducted from the upstream regions to the project target area, and therefore it is apparent that this project made a major contribution to flood control.

However, other factors have ensured that flood risk remains high in Jakarta despite the completion of these structural projects.

Population pressures

Since 1980 the population of Greater Jakarta has doubled from 11.9 million to 28 million. Every year, due to rural-urban migration an estimated 250,000 people relocate to the city. Due to population pressures half of the city's small lakes (waduk) have been converted into residential or commercial areas, leading to severe reductions in retention capacity and increases in peak discharge. Jakarta's flood control systems are also adversely affected by weak enforcement of urban and spatial plans and building regulations, as well as uncontrolled abstraction of groundwater.

Insufficient maintenance and improper operation of flood control systems

The Ministry of Public Works (MoPW) and DKI (i.e. City of Jakarta administration) are responsible for maintaining flood control infrastructure. However, due to lack of financial resources the maintenance of the system is insufficient. This has resulted in huge sediment build-up in primary floodways and drains, reducing protection levels from 1:25 years to less than 1:5 years.

Limited coverage of solid waste collection services

The rapid population increase resulted in an increase in solid waste. DKI collects less than 40 percent of the solid waste generated, and about 15 percent of Jakarta's total solid waste (about 1,000 tons per day) is discarded into the city's canals. Waste water discharge into the canals adversely affects water quality and contributes to water-borne diseases.

Lack of coordination between authorities responsible for flood management

MoPW and DKI are responsible for managing Jakarta's flood control system. MoPW is responsible for floodways that cross provincial boundaries, while the Public Works Department of Jakarta is responsible for drains and retention basins within its boundaries. Nevertheless, MoPW do not adequately allocate financial resources to maintain floodways under its control, and as a result DKI needs to allocate its resources to maintain the floodways as well. In term of spatial planning, there is also a lack of coordination between regencies in Jabodetabek (Greater Jakarta). In the case of flooding, water resources planning and coordination within Jabodetabek become the key aspect that needs to be taken into account.

Land Subsidence

Recent evidence confirms that some areas of Jakarta are subsiding rapidly, with future minimum subsidence predicted to be five to 10 centimeters per year. This has resulted in an increased risk of coastal inundation and necessitated the construction of a new stretches of sea wall, as well as increasing the height of the existing defenses. Subsidence also results in lowering reduction of clearances of structures over the canals (such as bridges) which also obstruct flows. Recent study conducted by DKI shows that subsidence in Jakarta is mainly caused by deep ground water extraction; in addition the load of structures and tectonic activities also contributes to the sinking of the city.

Jakarta Comprehensive Flood Management

Further flood control and mitigation projects are planned covering the whole spectrum of structural and non-structural measures. Some of these projects are regarded as urgent while others are longer term and are now the subject of extensive risk assessment and scenario evaluation. For example, the speed of construction of an elevated toll road to the airport was increased, in order to safeguard its accessibility. The scheme is designed to use the expected revenue from the tolls to finance the construction of the flood protection. Figure 7.5 below shows the range of existing and planned activity regarding Flood Risk Management in Jakarta.

Major initiatives include the Jakarta Urgent Flood Mitigation project/Jakarta Emergency Dredging Initiative Project (JUFMP/JEDI Project), Jakarta Coastal Defense Strategy and the Jakarta Comprehensive Flood management plan which are tackling flood risk respectively within the city, upstream of the city and at the city-coastal interface. Other more local initiatives are also cutting across these strategic projects and tackle issues such as waste management and ecological issues.

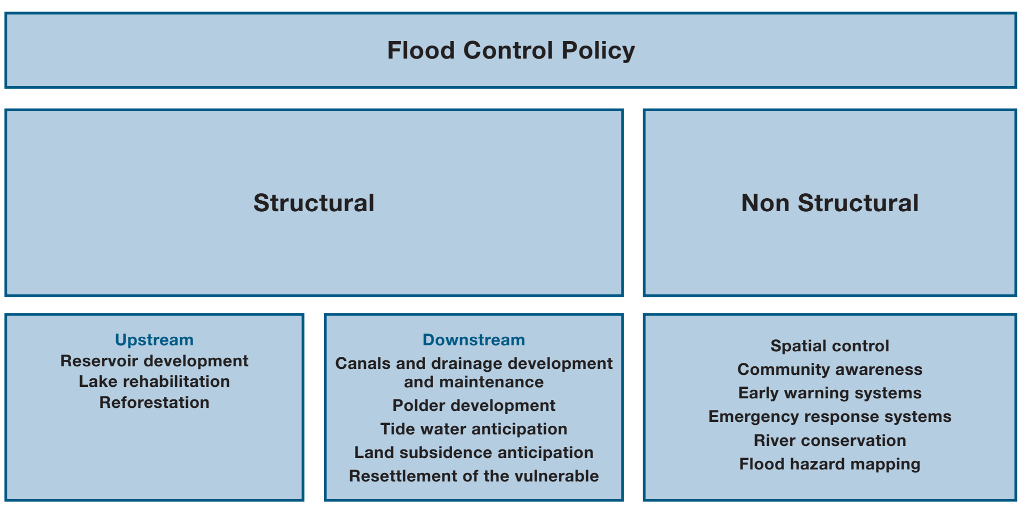

Figure 7.5: Flood control policy elements for Jakarta.

Jakarta Urgent Flood Mitigation Project/Jakarta Emergency Dredging Initiative (JUFMP/JEDI Project)

The objective is to improve the operation and maintenance of priority sections of Jakarta's flood management system. There is also a need to upgrade the management information systems and early warning systems, and to introduce a scheme for safe disposal of dredged material using a combination of sorting, disposal in land reclamation sites and a licensed hazardous waste disposal facility. The project is run by Central Government (Ministry of Public Works) and DKI Jakarta supported by the World Bank. Challenges with resettlement and the need to conduct open and transparent consultations and negotiations over compensation and redress have delayed the program which is now planned to start physical works in early 2012.

Jakarta coastal defense strategy

This project is aimed towards building flood risk strategy which can protect Jakarta, in the long term, from the dual impact of sea level rise and land subsidence. Short term coastal defense is also re-evaluated in the study. In the short term, urgent coastal defense actions include new and heightened seawalls and redesign of coastal pumps and gates. These will need to continue. At the same time, long term climate projections and the expected impact of continued groundwater extraction are combined to give scenarios of future flood risk. Options have been identified as suitable to mitigate future flooding under various climate and subsidence conditions. As these include major offshore coastal defenses, groundwater controls and the building of new and larger retention areas in the city, all of the options identified will require preparation or lead time. Therefore the project aims to provide a clear direction as to the transition triggers from one future defense strategy to the other, in terms of sea level and the subsidence actually observed.

Photo 7.3: Scavenging on Jakarta's Waste. Photo from JUFMP/JEDI, Source: WB/Asnaap

Jakarta Comprehensive Flood Management.(JCFM): The Project for Capacity Development of Jakarta Comprehensive Flood Management

This JICA-funded project includes facilitating the implementation of the Zero delta Q policy – that construction of new buildings should not result in increased water discharge (Government regulation 26 on national spatial planning). This is only possible with a comprehensive plan involving cooperation between upstream and downstream areas and including zoning of areas, construction of infiltration measures to recharge groundwater and regulations on upstream areas to solve a downstream problem. The project will build on existing catchment wide modeling of run off to design a sustainable system of run-off allocation.

Insurance schemes – Insurance is available for flooding in Indonesia. However in the aftermath of a major flood event in the city it is sometimes difficult and expensive to obtain. A micro-insurance scheme was designed to offset the cost of flood damage for the poor in Jakarta. However this innovative product was discontinued as the cost of the policy was too high. Adequate risk financing for Jakarta is an area where more effort may be directed.

Community based FRM initiatives includes:

- Pilot projects in canal and gutter cleaning services and solid waste management, producing marketable products such as organic compost.
- Flood preparedness training.
- Practical handbook for the community.

Capacity building to prevent and manage future flooding also includes:

The provision of an integrated waste management facility. Located in Bantar Gerbang and Ciangir Tangerang, this will divert municipal solid waste from Jakarta.

Waste management and recycling schemes

Community flood early warning system in Kebon Baru. This project strengthens the existing Jakarta wide Flood Early Warning System for local action. This includes the corroboration of flood warnings by local wardens using flood warning poles.

Dashboard Jakarta: is an innovative pilot project looking at the way in which meteorologically based forecasts of flooding can be combined with local intelligence via social media such as Facebook and Twitter to provide a mobile application suitable for alerting the residents and managers of Jakarta about upcoming and existing patterns of flooding in the city.

Mangrove Plantation recovery program

Groundwater extraction controls - are being introduced slowly, as cutting off all extraction would leave large parts of the population without any supply. Tariffs for hotels and businesses have been increased in line with piped water prices.

Policy lessons

- Past structural measures have reduced risk but significant residual risk remains
- A diverse approach including non structural and structural measures is necessary
- Urbanization and land subsidence are more urgent issues for Jakarta than future sea level rise
- It is a challenge to implement a truly integrated approach given that at least 30 organizations have been involved in recent studies and projects.
- Experience shows that it is not easy to scale up community-based activities to a city scale. Some examples of best practice at a local level could be spread more widely around the city,
- The experience of previous structural projects demonstrate that, in a megacity such as Jakarta, the scale of city-wide projects to install

structural measures suffer from very long lead in times. Forward planning needs to be flexible and incorporate scenario testing as in the JCDS.

– On the other hand, an even more comprehensive integrated solution combining downstream, midstream and upstream retentions would be more effective in order to anticipate possible intense rainfall within this large catchment, subsidence along the coast, and sea level rise.

Sources: Mercycorps (2011); Handhayani (2009); Fook Chuang Eng (2011); Brinkmann (2011); Nasir, H. 2008, Rukmana 2010.; Haryanto, U. (2009); Jakarta Post, the (2003). Japan International Cooperation Agency (JICA). World Bank (2008); Tucci (2009); WHO (2007); BAPPENAS;

7.6. Final remarks

This guide has addressed the challenge of integrated flood risk management to prevent and recover from large and increasing flood risk in urban areas. Living with flood risk is a devastating reality for a large and growing number of people in the world, but it is not the only or even the most urgent challenge which they face day to day. There are many reasons that may result in the priority of flood risk management being ignored in favor of more immediate demands. There are financial, practical and psychological factors that come into play here, including the common perception that flooding will not happen.

As the guide advocates an integrated approach to flood risk management, it follows that in a successful system, flood risk awareness, perception and good practice will be high. Moving from the current situation to the integrated ideal will often involve a painful process necessitating changes of mindsets and motivations for multiple stakeholders, and the balancing of their relative needs and priorities. The benefits of the integration of flood risk management into wider urban management, urban planning and climate change adaptation are clear but there are also dangers involved when flood management becomes subsumed as part of a larger role and there has not been a flood for a while.

Flood risk management therefore needs champions at the city, regional, national and international level in order for it to be brought to the table, as appropriate, in major developmental decision making processes. Issues with a strong champion in a position of influence tend to be more successfully addressed in general

(Bulkeley et al. n.d.). For an often high impact, low frequency risk like flooding, the need for advocacy is even more critical. A body with an oversight role is also helpful, as is the timetabling of regular reviews of national disaster, emergency, resilience and adaptation planning if the consideration of flood management is embedded in those plans.

It must be recognized that even repeated awareness campaigns, flood warnings and general advice will not always engender actions. Inertia is common to institutions and populations at risk and the situation is made worse by the future uncertainty which is perceived to dominate decisions in this area. The most successful long-term flood risk management strategies will balance the implementation of short-run, quick gain, non- structural measures with a vision of the best suite of structural and non- structural measures to be implemented for the longer term. Understanding the required resources, the best and worst case scenarios and the tipping points at which action becomes imperative, rather than justified, can lead to better decisions. In addition acknowledging those actions which will simply never be feasible can help in producing real practical solutions day to day.

As the case studies in this volume reveal and research has often shown, concerted effort and financing applied towards flood risk reduction is often only triggered after a major flood event – and for a relatively short time afterwards. Other opportunities to make significant investment can arise through less reactive and more proactive initiatives such as urban regeneration projects, flagship buildings or climate adaptation programs (Bulkeley et al. 2009). A change of administration, international agreements or major disasters elsewhere can also spark initiatives. Global networks such as city associations or even the potential for investment by global international businesses can create impetus and funding streams.

Whatever the source of the window of opportunity, the timescale to plan and implement change on the back of heightened awareness is generally short. Conversely the best practice in relation to evaluating options, undertaking consultations and stakeholder engagement has a relatively long lead time. Having the vision for integrated flood risk management in place in advance of when circumstances for change are favorable can be a factor in successfully exploiting any such opportunity as it arises.

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Abbreviations

ACCCRN	Asian Cities Climate Change Resilience Network
ADPC	Asian Disaster Preparedness Center
ADRC	Asian Disaster Reduction Centre
AEP	Annual Exceedance Probability
AfDB	African Development Bank
AIP	Annual Investment Program
ALARP	As Low As Reasonably Practical
ALERT	Automated Local Evaluation in Real Time
ALPHALOG	L'Association Libre pour la Promotion de l'Habitat et du Logement
AR4	Fourth Assessment Report (of the IPCC)
ASP	Alandur Sewerage Project
BAPPENAS	Indonesia's National Development Planning Agency
BCPR	Bureau of Crisis Prevention and Recovery
BCR	Benefit Cost Ratio
BDCCs	Barangay Disaster Coordinating Councils
BGCP	Business and Government Continuity Plan
BMP	Best Management Practices
BMTPC	Building Materials and Technology Promotions Council
BOM	Bureau of Meteorology (Australia)
BOQ	Bill of Quantities basis (contractual term)
BOT	Build, Operate and Transfer basis (contractual term)
CBA	Cost Benefit Analysis
CBDRM	Community Based Disaster Risk Management
CBO	Community Based Organization
CDERA	Caribbean Disaster Emergency Response Agency
CFMC	Community Flood Management Committee
CIDA	Canadian International Development Agency
CPNI	Centre for the Protection of National Infrastructure

CRED	Centre for Research on the Epidemiology of Disasters
CWC	Central Water Commission (India)
DaLa	Damage Loss Assessment methodology
DFID	Department for International Development (UK governmental body)
DGPC	Algerian Civil Protection Agency
DGPS	Differential Global Positioning System
DipECHO	Disaster Preparedness Programme of the European Commission's Humanitarian Aid department
DRF	Data Request File
DSC	Data Storage Centre
DSM	Digital Surface Model
DSS	Decision Support System
DST	Decision Support Tools
DTM	Digital Terrain Model
DWF	Development Workshop France
ECHO	EU Humanitarian Aid Department
EFFS	European Flood Forecasting System
EM-DAT	Emergency Events Database
EPM	Environmental Planning and Management
EROS	Earth Resource Observation System
ESA	European Space Agency
EWS	Early Warning System
FAO	Food and Agriculture Organisation of the UN
FEMA (US)	Federal Emergency Management Agency
FEWS	Flood Early Warning System
FMU	Flood Management Unit
FRM	Flood Risk Management
GCM	Global Climate Models
GDIN	Global Disaster Information Network

GDP	Gross Domestic Product
GDPFS	Global Data Processing and Forecasting System
GFDRR	Global Facility for Disaster Reduction and Recovery
GHGs	Greenhouse Gases
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GLOF	Glacial Lake Outburst Floods
GNP	Gross National Product
GOY	Government of Yemen
GPS	Global Positioning System
GUI	Graphical User Interface
GWP	Gross World Product
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HEPS	Hydrological Ensemble Prediction Systems
ICHARM	International Centre for Water Hazard and Risk Management
IFMS	Integrated Flood Management Strategy
IFRC	International Federation of Red Cross and Red Crescent Societies
IIRS	Indian Institute of Remote Sensing
ILWIS	Integrated Land and Water Information System (a software package from ITC)
INGC	National Institute of Disaster Management (Mozambique)
IOC	Indian Ocean Commission
IP-CCTV	Internet-protocol closed-circuit television
IPCC	Intergovernmental Panel on Climate Change
IRIN	Integrated Regional Information Networks
IUCN	International Union for Conservation of Nature
IWPDC	*International Water Power and Dam Construction* (periodical title)

KBMS	Knowledge Based Management System
KDRRI	Kailali Disaster Risk Reduction Initiatives
LGU	Local Government Units
LID	Low Impact Development
LIDAR	Light Detection And Ranging
MBES	Multi Beam Eco-Sounder Surveying
MBMS	Model Base Management System
MCA	Multi Criteria Analysis
MDGs	Millennium Development Goals
MFI	Market-based Financial Institution
MMDA	Metropolitan Manila Development Authority
MRC	Mekong River Commission
NADI	GFDRR funded IFM project in the Philippines
NASA	National Aeronautics and Space Administration
Nat-CatSERVICE	Munich Re database of natural catastrophe losses and associated services
NATMO	National Atlas and Thematic Mapping Organization
NFIP	National Flood Insurance Program (USA)
NFIs	Non Food Items
NGO	Non Governmental Organization
NHWC (US)	National Hydrologic Warning Council
NMHS	National Meteorological and Hydrological Services
NOAA (US)	National Oceanic and Atmospheric Administration
NSIDC (US)	National Snow and Ice Data Centre
NWS (US)	National Weather Service
O and M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
Ofwat	Official body regulating water and sewerage providers in England and Wales
ORT/ORS	Oral Rehydration Therapy/Oral Rehydration Salts
PDNA	Post Disaster Needs Assessment

Periperi	Partners Enhancing Resilience to People Exposed to Risk (South Africa)
PLA	Participatory Learning and Action
PPP	Public-Private-Partnership(s)
PRA	Participatory Rural Appraisal
PREDES	Network for social studies on disaster prevention in Latin America
PROMISE	Program for Hydro-Meteorological Disaster Mitigation in Secondary Cities in Asia
PROSAM	Sanitary program of Brazil
PTSD	Post Traumatic Stress Disorder(s)
PWRI	Public Works Research Institute (Japan)
RCM	Regional Climate Model
RTK-GPS	Real Time Kinematic GPS
SAR	Synthetic Aperture Radar
SFM	Stream Flow Model (S Africa)
SHOALS	Scanning Hydro-Graphic Operational Airborne LIDAR Survey
SINAGER	Sistema Nacional de Gestion de Riesgos
SMART	Stormwater Management and Road Tunnel
SRES	Special Report on Emissions Scenarios (of the IPCC)
StEB	Group of Municipal Drainage Operations Cologne (Stadtentwässerungsbetriebe Köln)
SUDS	Sustainable Urban Drainage Systems
SWAN	Simulating Waves Nearshore
TE2100	Thames Estuary 2100 project (UK)
TFP	Total Factor Productivity
TRCA	Canadian flood forecasting system (Toronto and region Conservation)
UN-ECLAC	UN Economic Commission for Latin America and the Caribbean
UN-HABITAT	United Nations Human Settlements Programme

UNCHS	Also known as the UN-Habitat organization
UNDHA	United Nations Department of Humanitarian Affairs
UNEP	United Nations Environment Programme
UNEP/SEI	United Nations Environment Programme/Stockholm Environment Institute
UNFCCC	United Nations Framework Convention on Climate Change
UNOCHA	UN Office for the Coordination of Humanitarian Affairs
UNOSAT	UNITAR'S Operational Satellite Applications Programme
UNISDR	UN International Strategy for Disaster Reduction
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USVI	United States Virgin Islands
VSL	Valuation of a Statistical Life
WASH	Water Supply, Sanitation and Hygiene promotion
WDR	*World Development Report*
WGCCD	Working Group on Climate Change and Development
WHO	World Health Organization
WMO	World Meteorological Organization
WRC	Water Resources Commission (Ghana)

Glossary

Actuarial: pertaining to statistical computations, such as those used for mortality rates and insurance calculations

Algal bloom: (or marine bloom or water bloom) is a rapid increase in the population of algae in an aquatic system; may be of concern as some species of algae produce neurotoxins

Aquifer: an underground bed or layer of permeable rock, sediment, or soil that yields water.

Attenuation: reducing the peak of flood flow, typically by slowing discharge rate (via storage in ponds, balancing lakes or similar)

Barnier Law/Barnier funds: special valuation scheme for flood-prone and flood-damaged properties found in French legislation

Bioaccumulation: the accumulation of substances, such as pesticides, or other organic chemicals in an organism

Biomass: biological material derived from living, or recently living organisms. In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material

Bourn(e): stream or brook that only flows for part of the year

Cadastral Map: map showing registered property with ownership, tenure, precise location, dimensions (may include GIS coordinates) and values etc – eg UK Land Registry records. (Alternate spellings of root word include 'cadaster' and 'cadastre')

Catchment: see Watershed

Coping Capacity: the means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human induced hazards

Culvert: covered channel, or large pipe, to convey water below ground level (for example, under a road, railway or urban area, also beneath a building or other structure)

Disdrometer: instrument used to measure the drop size distribution and velocity of falling precipitation (rain, hail, snow, sleet)

Downstream: that part of a channel nearer to the sea than the reference point; travelling with the normal direction of flow

Ex ante flood measures: actions taken in advance of flooding (to prevent damage occurring)

Ex post flood measures: actions taken after flooding has occurred (eg to mitigate damage, prevent further damage occurring)

Exposure: people, property, systems, or functions at risk of loss exposed to hazards

Filter strip: gently sloping area of vegetated land, delaying and reducing stormwater peaks, and trapping pollutants and silts

Floodplain: area of nearly flat land bordering a river that is partly, or wholly, covered with water during floods

Gabion: container made of wire, plastic mesh (or similar material), filled with stones, used to form retaining wall or provide protection against scour

Geotextile: permeable fabric (synthetic or natural) used in conjunction with soil for the function of filtration, separation, drainage, reinforcement or erosion protection

Giorgi regions: sub-continental regions of the world as defined by Giorgi and Francisco (2000):

A: Australia

B: Amazon Basin

C: Southern South America

D: Central America

E: Western North America

F: Central North America

G: Eastern North America

H: Alaska

I: Greenland

J: Mediterranean Basin

K: Northern Europe

L: Western Africa

M: Eastern Africa

N: Southern Africa

O: Sahara

P: Southeast Asia

Q: East Asia

R: South Asia

S: Central Asia

T: Tibet

U: North Asia

Giorgi, F. and Francisco, R. 2000. "Uncertainties in regional climate change prediction: a regional analysis of ensemble simulations with the HADCM2 coupled AOGCM." Clim. Dyn. 16: 169-182.

Groundwater: water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. The upper surface of groundwater is the water table.

Groyne: wall or embankment built out from the coast, or a river bank, to inhibit erosion of the shore or river bank (and in some cases to encourage accretion)

Hazard: an act or phenomenon that has the potential to produce harm or other undesirable consequences to some person or thing

Internally displaced persons (IDPs): someone who is forced to flee his or her home but who remains within his or her country's borders (sometimes incorrectly termed refugees)

Kabari: scrap dealer (term used in Pakistan)

Kanungkong: a bamboo instrument traditionally used to call community members to assemble, to alert people or call children home, now used for flood early warning system as well (term used in Philippines)

Levee: an embankment raised to prevent a river from overflowing.

Meander: natural process of deviation of a river or stream from a straight course, in which silt is deposited on the inside of the bend (accretion) and erosion occurs on the outside

Mitigate/mitigation: the use of reasonable care and diligence in an effort to minimize or avoid injury; to take protective action to avoid additional injury or loss

Polder: regions of land that are inundated when the capacity of the soil to absorb water is saturate

Rainwater harvesting: accumulating and storing rainwater for reuse before it reaches the aquifer

Re-profiling (of a river bank, or embankment): change the degree of slope (for example, to make a flood bank flatter and more stable)

Resilience: the capacity that people or groups may possess to withstand or recover from emergencies and which can stand as a counterbalance to vulnerability

Return period: average interval of time between years in which events occur that equal, or exceed, a given magnitude

Riparian owner: owner of land bordering a watercourse; may have legal rights and responsibilities relating to water flow or water quality because of this

Riparian: land bordering a watercourse

Risk: the probability of harmful consequences or expected losses resulting from a given hazard to a given element at danger or peril over a specified time period

River Basin: see 'Watershed'

Scour(ing): erosion resulting from the shear forces associated with flowing water and wave action (typically river bed scouring downstream of structures such as bridges or outflow pipes)

Seiche: standing wave in an enclosed or partially enclosed body of water

Soakaway: depression into which surface water percolates

Staff gauge: graduated scale placed in a position so that the surface level of a water body relative to a fixed point (eg sea level) can be read off

Sustainability: forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs

Swale: grass-lined channel which allows the infiltration, storage and conveyance of stormwater

Swale: low-lying depression or 'ditch' typically in moist/marshy area; does not convey water, but allows it to be absorbed by the ground (infiltrate) gradually

Tahsil: administrative divisions (term used in some areas of Asia especially parts of India)

Tributary/tributaries: smaller watercourse(s) joining a larger one, thus adding to total flow (the meeting point is a 'confluence')

Upstream: that part of a channel nearer to the source of the watercourse than the reference point; travelling opposite to the normal direction of flow

Urban heat island effect: urban areas are significantly warmer than the surrounding rural areas; temperatures can vary across a city depending on the nature of the land cover, such that urban parks and lakes are cooler than adjacent areas covered by buildings

Vulnerability: the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard

Wadi: a dry channel except in the rainy season/winter season (North African regional term)

Watershed: is an extent, or an area of land, where surface water from rain and melting snow, or ice, converges to a single point, usually the exit of the basin, where the waters join another waterbody (such as a river, lake, reservoir, estuary, wetland, sea, or ocean). Other terms include catchment area, catchment basin, drainage basin, drainage area, river basin and water basin

Note: technical definitions derived from CIRIA 2002. C551 Manual on scour at bridges and other hydraulic structures. London: CIRIA.

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