Guide for preparation of flood risk management schemes

Funded by the European Investment Bank

December 2007

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Summary

This document provides advice related to fluvial flood risk management that addresses strategic planning, environmentally sensitive design and the implementation of works. The purpose of the guide is that it should provide approaches to ensure compliance with EU standards and environmental practices. It is expected that following the guidance provided below will expedite the consideration of funding for flood risk management made to the EIB.

This guide offers a general approach to delivering fluvial flood risk management (FRM). It is not an engineering design guide.

The topics that are addressed include:

Strategic flood risk management – a major factor in FRM within Europe is the relevant EU legislation, including the Floods Directive and the Water Framework Directive together with various of the environmental directives, including the Habitats and Birds Directives, the Strategic Environmental Directive and the Environmental Impact Assessment Directive. These set the context for an overall strategy of FRM. Such strategies should be catchment or region based and so in the case of trans-boundary rivers there is a need for collaboration of all the institutions involved. Implementation of FRM requires the existence of national legislation to provide powers to the relevant implementing authorities. There are a wide range of potential approaches to funding FRM, which are outlined. The selection of an approach depends upon many factors including the nature of the flooding and the social attitudes of the country.

Flood Risk Management practice within Europe – the implementation of FRM throughout Europe varies widely, though the underlying philosophy of FRM is common. This variation in implementation arises from a number of sources, including;

a) the nature of the flood risk is different in different countries
b) the nature and quality of data that is available varies
c) social attitudes vary between countries
d) the concepts and methods of FRM are rapidly developing and their degree of implementation varies.

Flood risk management within a river basin – the role of modelling is central to determining an optimum basin-wide FRM plan. The available options that need to be considered in developing such a plan include: structural and non-structural methods, flood forecasting, land use zoning and planning and flood resilience. The integration of SEA within the process of developing catchment FRM plans is important in order to take opportunities to protect and enhance the environment. An important aspect of the SEA process are actions to promote public awareness, consultation and participation. It is important that at this strategic level well founded methods for option appraisal and selection are used.

Selection of flood risk management options – methods are available that can be used to select, prioritise and appraise flood risk management options. Though there are a number of different approaches that can be used a common component is the use of Cost-Benefit analysis (CBA) and Multi-Criteria analysis (MCA). The use of Cost-Benefit analysis ensures that schemes are economically justified while Multi-Criteria analysis can be used to ensure that decisions are not just taken purely on an economic basis. In a number of countries the data required to apply such methods rigorously is not yet available. In these cases short-cut methods can be used to carry out option ranking and appraisal but it should be appreciated that these may lead to sub-optimal decisions being made and it is recommended that the long-term aim should be to use CBA and MCA.

Summary continued

Implementation of projects – the issues of detailed design, approvals and permits, and construction supervision are important for the final success of schemes. It is essential to ensure that schemes are constructed according to the designs that have been prepared.

Operation and maintenance – it is common for there to be a divide between the design of a project and the subsequent maintenance and operation. This can mean that schemes do not perform as originally designed. It is necessary to ensure that appropriate operation and maintenance of schemes is carried out consistent with the original design.

Institutional framework – the institutional requirements for the implementation of FRM are described. The institutional arrangements for FRM throughout Europe are highly country specific and often complex with responsibility for different aspects of FRM split between different institutions. In this situation it is of the utmost importance that steps are taken to ensure coordination between the relevant bodies. It is expected that in the future there will be an increasing convergence between the implementation of the Floods Directive and the Water Framework Directive. It is recommended that the present institutional framework is reviewed in order to promote such integration.

Flood emergencies – steps are required to ensure an adequate response during an emergency. It is important to plan the actions that are required in preparation before the event, the response during the event and the post flood recovery.

Abbreviations

AA	Appropriate Assessment
CBA	Cost Benefit Analysis
CRUE	Coordination de la recherche sur la gestion des inondations financée dans l'Union Européenne
DEFRA	Department for Environment, Food and Rural Affairs, (UK)
EC	European Commission
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EU	European Union
FRM	Flood Risk Management
FRMP	Flood Risk Management Plans
GWP	Global Water Partnership
GIS	Geographical Information System
MCA	Multi-Criteria Analysis
NGO	Non-Governmental Organisation
NRP	non-residential properties
SDS	Sustainable Drainage Systems
SEA	Strategic Environmental Assessment
SPV	Special purpose vehicle
UNECE	United Nations Economic Commission for Europe
WMO	World Meteorological Organization
WFD	Water Framework Directive

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1. Introduction

1.1 PURPOSE OF GUIDE

This guide has been prepared for the European Investment Bank (EIB) to provide advice on fluvial flood risk management that addresses strategic planning, environmentally sensitive design and the implementation of works. The purpose of the guide is that it should provide approaches to ensure compliance with EU standards and environmental practices. It is expected that following the guidance provided below will expedite the consideration of funding for flood risk management made to the EIB.

1.2 SCOPE OF GUIDE

This guide offers a general approach to delivering fluvial flood risk management (FRM). It is not an engineering design guide. For engineering advice reference should be made to relevant national and international design standards. Nor does it replace or supersede the Best Practices on Flood Prevention, Protection and Mitigation (Water Directors, 2003) but is intended to complement this.

This guide concentrates on providing general guidance. There are currently rapid developments on technical methods to be used in, for example, hydrology, flood modelling, flood forecasting, damage estimates and analysis. In any country the methods applied may vary depending upon the nature of the flood risk and the social values within the country. Details of available guidance manuals are presented in Annex 1 but it must be realised that the advice contained within them will rapidly date. For details on specific technical implementation reference should also be made to the results of on-going research and development. EC funded programmes such as CRUE (www.crue-eranet.net) should provide a means of obtaining up-to-date information about research developments on flood risk management across Europe. There is currently (2007) an on-going major EC funded research programme on flooding called FLOODsite (www.FLOODsite.net) which is looking at a wide range of flood-related issues. The outcomes of this project are expected to lead to further developments on thinking on flood risk management.

Box 1 Crue and Floodsite programmes

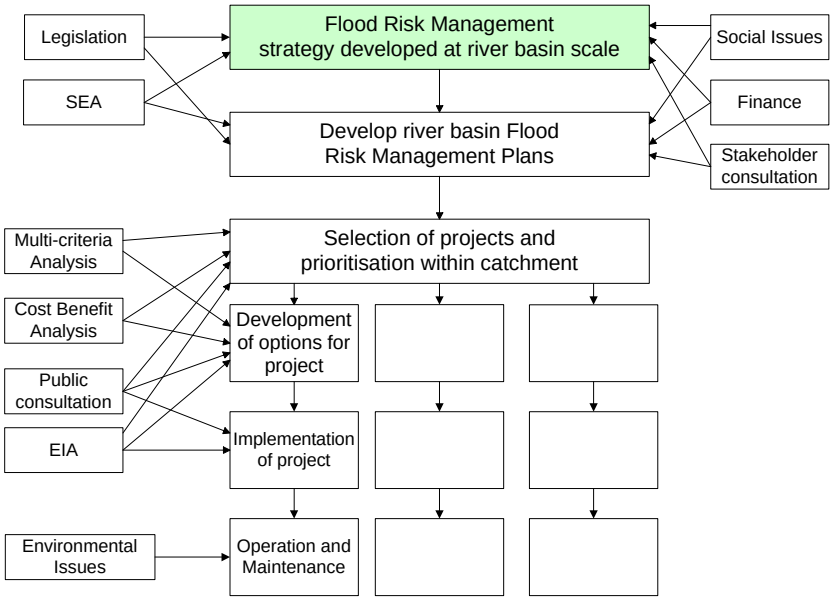
CRUE ERA-NET aims to introduce structure within the area of European Flood Research by improving co-ordination between national programmes. The vision for the CRUE ERA-NET action on flooding is to develop strategic integration of research at the national funding and policy development levels within Europe to provide knowledge and understanding for the sustainable management of flood risks. The CRUE network has been set up to consolidate existing European flood research programmes, promote best practice and identify gaps and opportunities for collaboration on future programme content. The CRUE project comes under the 6th Framework Programme of the Research DG and is of 4 years duration.
The FLOODsite project covers the physical, environmental, ecological and socio-economic aspects of floods from rivers, estuaries and the sea. The project is arranged into seven themes covering:

1. Risk analysis – hazard sources, pathways and vulnerability of receptors.
2. Risk management – pre-flood measures and flood emergency management.
3. Technological integration – decision support and uncertainty.
4. Pilot applications – for river, estuary and coastal sites.
5. Training and knowledge uptake – guidance for professionals, public information and educational material.
6. Networking, review and assessment.
7. Co-ordination and management.

See Annex 2 for further details of the FLOODsite project

2. Strategic flood risk management

2.1 FLOOD RISK MANAGEMENT: GENERAL CONCEPTS AND ELEMENTS OF A STRATEGY



In recent years the traditional policy paradigm of *flood defence* has evolved into *flood risk management*, a broader concept that includes management of flood plains, measures to retain flood water in harmless locations, land use planning, forecasting and warning systems, insurance, flood-proofing, and other measures, as well as the physical infrastructure to keep floodwaters away from populations and infrastructure.

Flood risk management has the following objectives:

- identifying and understanding the nature and extent of flood risks;
- understanding and addressing public perceptions of and reactions to flood risk;
- establishing goals and standards with respect to flood risk ('optimal risk');
- establishing strategies and policies to achieve these goals;
- minimize the costs involved while ensuring that existing and future developments are not exposed to 'unacceptable' risks;
- ensuring that developments do not increase the risks for the rest of the community.

EU policies on flood risk management have developed along these lines and in reaction to over-reliance on "hard" structural measures. The "best practice" document produced by a core group of EU Water Directors (Water Directors, 2003) echoes many themes of flood risk management (FRM). Floods are a natural phenomenon; flood strategy should cover the entire river basin; the paradigm must shift from defensive action to management of risks and living with floods; and there should be action, including trans-national efforts, to restore natural flood zones such as wetlands and floodplains. Although structural measures will remain important for protecting human health and safety, and valuable property and assets, defence can never be absolute, and mitigation and non-structural measures are often more sustainable solutions in the long term.

The "Best practice" paper (Water Directors, 2003) urges that human uses of floodplains should adapt to the likely hazards. Authorities should provide adequate flood warning, forecasting and relevant information. Public preparedness should remain high. Victims of floods should be compensated, and

public and private insurance schemes should be considered. The principle of solidarity is supported – water management problems should not be passed on from one region to another. So far as possible, floodwater should be retained, stored and slowly released. This may be achieved in a number of ways. Land use may affect the amount of infiltration and the speed of runoff. Water can be temporarily stored before draining into water courses. Once in water courses, floodplains can be used to provide temporary flood storage. Preventive measures should be taken to reduce adverse impacts of floods on aquatic and terrestrial ecosystems.

The abovementioned "Best practice" paper emphasised the following elements of Flood Risk Management:

1. an integrated approach to the whole river basin
2. public awareness and participation
3. insurance
4. provision of flood water storage within the river basin utilising natural storage within the catchment and use of non-structural measures
5. land use zoning
6. risk assessment
7. structural measures
8. flood forecasting and warning
9. flood emergency planning
10. pollution issues arising from floods

Within the EU the development of FRM practises is being driven by the Floods Directive. This will set the framework for future FRM throughout Europe. The development of the Floods Directive indicates the magnitude of the economic and social impacts of flooding throughout Europe and the recognition of the need to manage these risks.

The impact pf flooding is already a major issue throughout Europe but there is concern that future climate change may exacerbate existing flood risks (Commission of the European Communities, 2007). Future climate change may modify flood risk into the future and it is important that present management strategies should take the potential for future change into account.

Defining Good Practice for Flood Risk Management

EU Member States exhibit great variety in their policy and practice of FRM and it would he hard to identify one model of best practice for emulation elsewhere. A more realistic approach is to accept that each country will evolve FRM in the light of its own circumstances. "Good practice" outcomes will differ, but each country should nevertheless strive towards good practice, interpreted and implemented in its own distinctive fashion.

This section rehearses some of the issues to be taken into account in building good practice in FRM, starting from recent influential statements of the EU Water Directors, the WMO and the Global Water Partnership (GWP).

FRM should be conceived within an integrated river basin approach, consistent with the EU Water Framework and Flood Directives. An integrated and comprehensive action plan should be prepared for flooding as for other aspects of river basin management, with international and trans-boundary cooperation arranged where appropriate.,

Stakeholder consultation is essential. Every person living in a flood risk zone is a legitimate stakeholder in decisions taken on FRM and a much wider population is affected by any measures taken. Some actions will impose costs and sacrifices on specific sections of the population and it is

important to get a wide degree of support for such measures. Key EU Directives require that public consultation procedures be followed.

Public awareness and participation is essential to proper flood risk management. Public engagement and support for FRM should be promoted by appropriate use of the media, civic education, schools and publicity based on flood hazard maps, GIS data, etc. Preparedness for flooding inevitably involves local communities, their networks and institutions. The general public should be encouraged to take their own FRM measures, where appropriate.

There should be clear principles about compensation & insurance. Financial compensation to flood victims to cover the cost of damage, disruption and distress can either be provided by society, through grants and soft loans, or from insurance policies operated by private (or public) companies. There is no consensus about the appropriate role of these two sources, and different countries reach their own balance between the two in practice. Policies should be clear, consistent, and humane, as well as avoiding "moral hazard". Insurance is considered in more detail in section 2.4.

FRM consists of a hierarchy of complementary measures: all should be considered. They broadly consist of actions to reduce flooding, measures to reduce susceptibility to damage, mitigating the impacts of floods, and preserving the natural resources of flood plains (Table 2.1.)

Table 2.1 Strategies and options for flood risk management

Strategy	Options
Reducing flooding	Dams and reservoirs Dykes, levees, embankments High flow diversions Catchment management Channel improvements Restoring natural floodplain storage
Reducing susceptibility to damage	Flood plain regulation Development policies Design & location of facilities Housing and building codes Flood-proofing Flood forecasting & warning Flood insurance
Mitigating the impacts of flooding	Information & education Disaster preparedness Post-flood recovery Flood insurance
Preserving the natural resources of flood plains	Flood plain zoning & regulation

Source: "Integrated flood management: concept paper. WMO & GWP 2004

Non-structural measures can play an important role. The storage value of vegetation, soil, ground and wetlands should be recognised and promoted, leading to improved river basin land use and prevention of rapid run-off. Preservation and enhancement of vegetation, forests, wetlands and floodplains should be a priority. Flood retention areas and dry polders may be part of this strategy. Restoring natural floodplain storage, the provision of additional floodplain storage, the removal or setting back of flood defences in certain areas, the restoration of the connection between river and floodplain as well as the creation of new flood retention areas and dry polders might all also be part of this strategy.

Spatial planning has to resolve difficult choices between land use and FRM. Flood-prone areas are often economically productive and attractive for habitation, creating a tension between economic and social uses, on the one hand, and minimising flood risk, on the other. Measures should be realistic:

inhabitants need to be made aware of flood risks to which they are exposed and should be encouraged to become "flood compatible". New building in high flood risk areas should be discouraged, where there are feasible alternatives.

While structural measures will continue to be necessary in many locations, they may create a false sense of security, and even encourage unsound development of flood risk areas. Residual risk should be fully considered. Some structural measures may be unavoidable in high-risk situations, but the principle that measures in one area should not augment flood risk elsewhere should be observed. The maintenance and rehabilitation of existing structures should be programmed, though some older structures may no longer be appropriate. Non-permanent barriers may be part of the solution.

Once the broad lines of an FRM strategy have been filled in, *the choice of individual schemes should be made using transparent processes and objective criteria.* Multi Criteria Analysis (MCA) is increasingly favoured as a decision method. Economic cost-benefit and cost-effectiveness analysis is a valuable component of MCA and is reaching high levels of refinement for FRM purposes. Additionally, or alternatively, simple comparisons of option performance against a set of objectives agreed with key stakeholders can be used, especially for high level assessments where individual option information may be limited.

Early warning and forecast systems are vital. An effective and reliable system of flood forecasting and the dissemination of information and warnings may reduce risk to people and property. This should use all relevant state-of-the-art technology, though the value of traditional data and customary methods should not be overlooked. In large basins it is important to have good exchanges of information between upstream and downstream authorities and communities.

Flood emergency plans should be put in place. Comprehensive national and local contingency plans for dealing with flood emergencies are necessary. This should include regular joint exercises and feedback from actual events.

Pollution is inevitable, and one of the worst results of flooding: it should be anticipated and all possible mitigating measures taken. Floods disrupt water supply and sewage disposal. Water run-off is often highly polluted, and even toxic, where it occurs in areas where contaminating items are stored or used. Ideally, the latter should be confined to areas not at flood risk.

An FRM strategy should form a strategic framework within which more detailed flood risk management can be developed and carried out. This is illustrated in Figure 2.1. The overall strategy should be developed on a national or catchment basis and should provide the context for more detailed sub-catchment or regional flood risk management plans.

The 'sustainability' of flood risk management measures should be considered, this can cover long term maintenance and replacement requirements, overall energy consumption, and materials sourcing, as well as environmental constraints and opportunities. Wider benefits can often be derived from flood risk management, if considered early enough, for example habitat creation, fish migration improvement, recreation amenity, and urban regeneration opportunities.

A flood risk management strategy should form a strategic framework within which more detailed flood risk management can be developed and carried out, this is illustrated in Figure 2.1. The overall strategy should be developed on a national or catchment basis and should provide the context for more detailed sub-catchment or regional flood risk management plans.

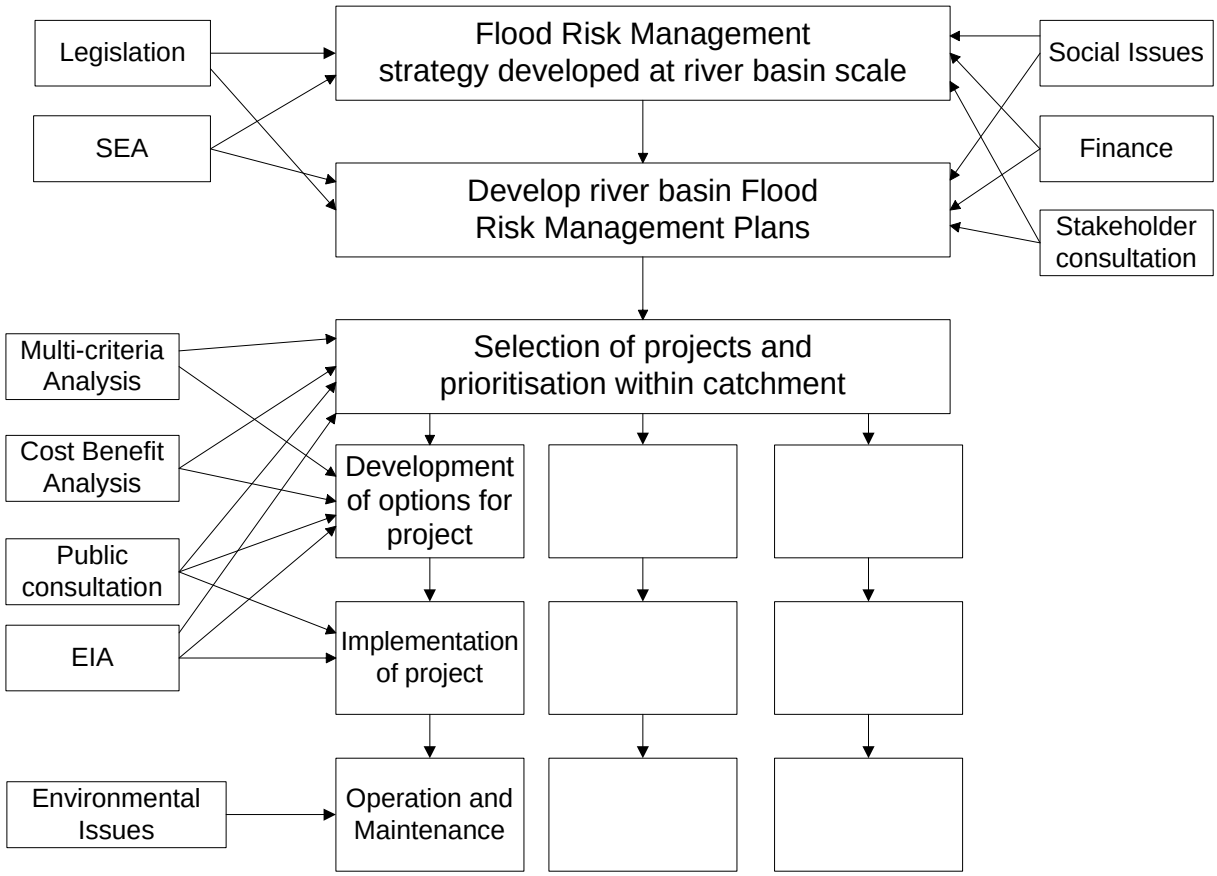


Figure 2.1 Steps involved in FRM

A *FRM* plan should not necessarily be limited to capital works but can encompass any programme of management action that influences flood risk. In many countries a distinction is drawn between capital works and on-going maintenance so that different staff and departments are involved in each activity and often each activity has a separate, distinct budget. There is a growing belief that the distinction between capital works and maintenance is artificial and the aim should be the optimum deployment of resources to provide flood risk management. Thus there are reasons to believe that the allocation of resources specifically to capital works or to maintenance is likely to lead to sub-optimal strategies.

The process of developing and implementing a strategy generally involves the following general stages:

1. Identification of problems and key issues
2. Establishment of strategic aims and objectives
3. Data gathering and analysis, consultation, option appraisal and resolution of conflicting interests
4. Decision on preferred policy and implementation options
5. Establishment of arrangements for ongoing monitoring, review and feedback to subsequent versions of the strategy.

This process is illustrated in Figure 2.2.

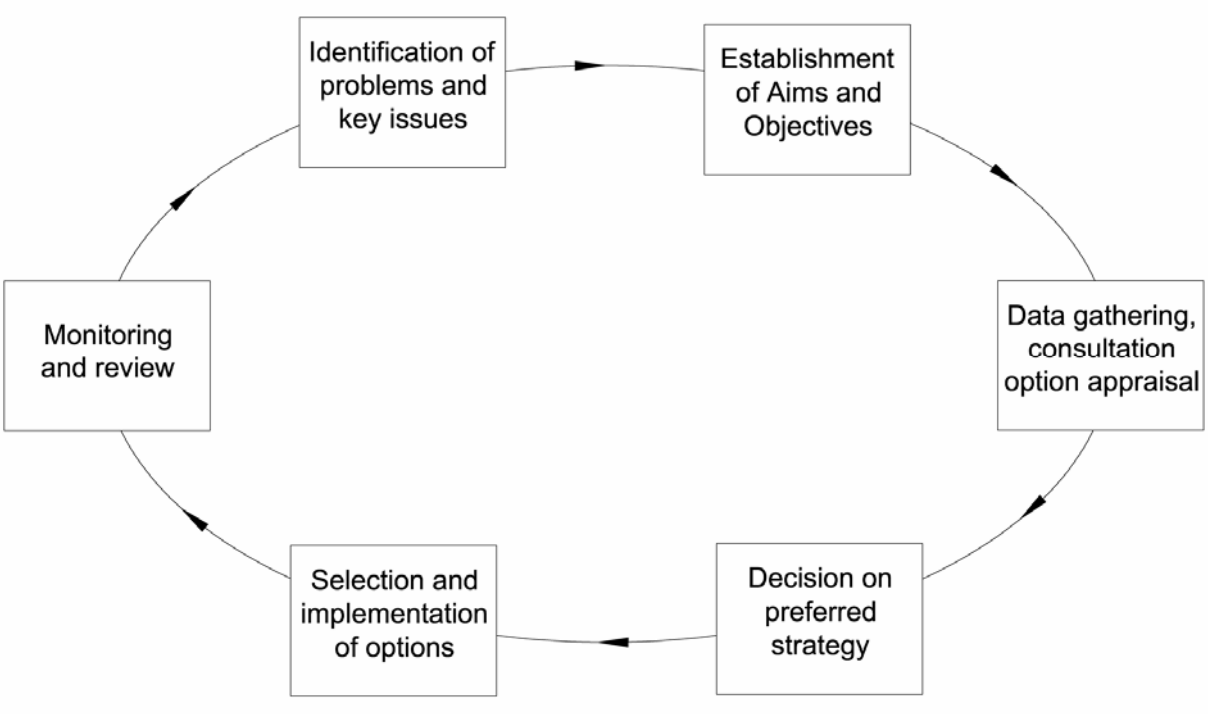


Figure 2.2 Process of developing and implementing an FRM strategy

Strategic planning on at least a catchment scale in relation to flood risk management is important as there can be a hydraulic connection between different areas within a catchment. Such connections may not always be obvious or readily apparent and some may only become known as the result of investigation. Planning on a catchment scale may also allow several different problems to be considered in an integrated way.

It is important that all potential impacts of possible schemes are considered, including, for example, environmental and social impacts. It should be noted that the European Directives relating to environmental issues include social and other impacts as part of the broad environmental impact. It is important that environmental considerations are taken into account in developing strategic plans. This allows environmental implications to be considered over whole catchments and cumulative effects to be included. Consideration should also be given to issues of sustainability, utilisation of energy and generation and disposal of waste.

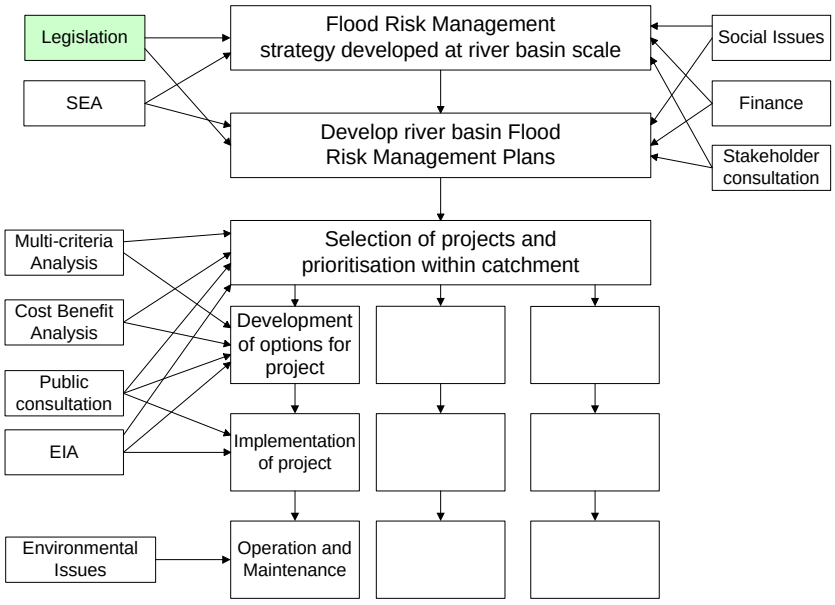
It is important that all these potential effects are considered as an integral part of developing and selecting options. Once an option has been selected then there are often limited opportunities to enhance positive impacts or to mitigate negative ones. In the context of flood risk management it is important that the initial development of options should be as wide as possible and should include upstream and possibly downstream options and the use of the widest possible range of techniques such as land use change, planning developments and flood warning or education should be included. Thus an environmental appraisal must be an integral part of the overall process of developing a flood risk strategy. It is important that the environmental acceptability of alternative schemes is integral to strategy development and that opportunities for environmental enhancement are considered at every stage.

The development and implementation of a Flood Risk Management Strategy is not a one-off exercise. Following implementation, the effectiveness of the measures taken should be monitored. In addition, hydrological information should be collected in order to further refine the assessment of the probability of flooding. Development within the flood zones may lead to changes in the vulnerability

to flooding. These in turn should feed back into reviews of the Flood Risk Management Strategy, see Figure 2.2. The EU Floods Directive recommends a six yearly cycle for review and up-dating.

A checklist for issues to be addressed during the process of developing Flood Risk Management Strategies is given in Annex 5.

2.2 RELEVANT EU LEGAL REQUIREMENTS



2.2.1 Floods directive

An EU Floods Directive (2007/60/EC) entered into force on 26 November 2007. The directive requires a coherent cross-border approach to minimising the risk of flooding by requiring EU Member States to work together to identify potential flood zones (such as river basins, inter-urban, areas, coastal and flash-flood paths), to exchange flood information and to coordinate their preventative efforts. Each Member State is required to undertake three actions. The first is to carry out a preliminary flood risk assessment of their river basins and associated coastal zones to establish existing and future flood damage potential on human health, economy, infrastructure and the environment. The second step involves the drafting of flood risk maps based on these analyses followed by a third (and final) phase creating a f*lood risk management plan* for each flood zone, irrespective of administrative boundaries. These will consider the local, regional and cross-border prevention[1], protection[2] and preparedness[3] measures necessary to prevent and limit the damaging effects of flooding.

The more detailed descriptions of these three actions are:

Preliminary flood risk assessment would include: a map of the river basin district; a description of past floods; a description of flooding processes, including retention areas and conveyance routes; an account of the relationship of development plans with flood risk; an assessment of the likelihood of future floods; and a forecast of the estimated consequences of future floods. Based on this information,

[1] avoiding construction of houses and industries in present and future flood-prone areas

[2] adapting future developments to the risk of flooding and support measures to reduce the likelihood of floods and/or the impact of floods in a specific location such as restoring flood plains and wetlands

[3] providing instructions to the public on how to react/respond in event of flooding

each river basin, sub-basin or stretch of coastline is considered either to incur potential significant flood risk, or not. This is required by December 2011.

Flood risk maps would be required for each river basin district for the 100 year flood and for extreme events. For each scenario data would be provided on water depths, flow velocity, number of victims, likely economic damage, potential environmental harm, etc. These maps would be required by December 2013.

Flood risk management plans would be drawn up for river basin districts where flood risk is considered to be potentially significant. The plans would address all phases of the flood risk management cycle, such as prevention, protection and preparedness, taking account of the characteristics of the basin in question. These plans would be required by December 2015.

The Directive requires reviews of these three actions every 6 years following initial deadlines. The timing of the implementation of the Floods Directive means that full harmonisation with the WFD should be achieved by the end of the first review exercise, 6 years after the initial implementation.

The initial deadline for meeting the environmental objectives set out in the WFD is at the end of Yr 2016[4]. The Floods Directive is closely allied with the WFD; as such, it is expected that its implementation and administration will be harmonised under existing Member State arrangements

"..The Commission proposes to fully align the organisational and institutional aspects and timing between the Directives, based on the river basin districts, the competent authorities and the committee established by the WFD. Timetables are fully synchronised which will ensure that the public consultation process is closely coordinated. …Member States may integrate the flood risk management plans into the river basin management plans…"[5]

The EU Floods Directive imposes on EU Member States the requirement to develop Catchment Flood Risk Management Plans.

It is expected that the Floods Directive will have significant impacts on certain aspects of Flood Risk Management. The requirement for the development of Flood risk maps and Flood Risk Management Plans will help to harmonise practice throughout Europe and lead to flood risk information being readily available. There is a requirement to prepare Flood Risk Management Plans but the Directive does not specify the nature of these plans. It is possible that different Flood Risk Management practices will persist throughout Europe and both the standard of protection and the methods by which it is achieved may vary widely.

2.2.2 Water Framework Directive

The floods directive and flood risk management need to be considered within the context of the Water Framework Directive (WFD). The WFD is a far reaching and comprehensive piece of legislation which provides the basis for achieving the sustainable management of water in the Member States. It was produced by the European Commission partly to address the rather fragmented nature of existing Directives, but also in order to achieve more effective implementation of water legislation and to respond to concerns over ecological quality and sustainability issues. A more comprehensive approach was, therefore, developed to take account of the need for:

- A high level of environmental protection, leading to a clean and healthy water environment.
- The 'precautionary principle' and the 'polluter pays' principle.

[4] a statutory 10 years after the Directive is enforced

[5] Directive, section 3, p. 5

- Taking preventative action against pollution and controlling pollution at source.
- Taking account of the costs and benefits involved within a fair water pricing policy.
- Ensuring that wide and active consultation takes place during the development of water management plans.
- The need for international collaboration for certain river basins

The WFD affects every aspect of water use and it requires actions by a wide range of players. Industry, agriculture, local authorities, planning bodies and others whose activities impinge on the water environment will be involved in the achievement and maintenance of environmental objectives that will be legally binding. At its core is the aim for member states to achieve the good quality status of water bodies. In addition to tackling point and diffuse sources of pollution and diffuse pollution, this will require, in some cases, changes in the hydro-morphology of water bodies or the reversal of past land drainage schemes, for example, to restore wetland and riverine habitats. There are thus both opportunities and challenges here for flood risk management.

Through WFD, the concept of river basin management is introduced to all Member States by the establishment of river basin districts as the basic management units. For international rivers these river basin districts (RBDs) transcend national boundaries. For each river basin district, a river basin management plan must be developed, including a programme of measures, and these will form the basis for the achievement of ecological protection and improvement. Although its prime aims are environmental, the Directive embraces all three principles of sustainable development. Environmental, economic and social needs must all be taken into account when river basin management plans are being developed.

With certain defined exceptions, the aim is to achieve at least good status for all water bodies in each river basin district. Good water status is achieved by a surface water body when both its 'ecological status' and its 'chemical status' can be classified as at least 'good'. Measures to conserve water quantity are introduced as an essential component of environmental protection. Unless minimal, all abstractions must be authorised and, for groundwater, a balance struck between abstraction and the recharge of aquifers. The river basin planning process is cyclical and the Directive requires periodic updates to the river basin management plans and associated programmes of measures on a six-yearly basis. The active involvement of interested parties is a core principle of the river basin planning process as defined in Article 14 of the Directive, in particular during the production, review and updating of the river basin management plans.

As noted in Section 2.2.1, the Flood Risk Management Plans required under the Floods Directive need to be coherent with the development of River Basin Management Plans.

The implication of the WFD on Flood Risk Management is that it is likely to influence the methods that are used to achieve Flood Risk Management and the techniques that are used. It is likely that in the future the use of hard engineering will decline while the use of soft engineering techniques and non-structural approaches will increase. It is likely that more use will be made of whole catchment approaches rather than concentrating on local solutions to particular flooding problems.

2.2.3 Habitats/Birds Directives

Flood risk management must take into account of the impacts of any proposed measures on the environment. EU Member States are required to comply with European Union legislation which provides for the protection for rare habitats and species. This legislation includes:

- Conservation of Wild Birds, Council Directive 79/409/EEC on the (the Birds Directive)
- Conservation of Natural Habitats and of Wild Fauna and Flora, Council Directive 79/409/EEC (the Habitats Directive).

The aim of the Habitats Directive is for habitats and species identified as of European wide interest to be maintained at, and where necessary restored to, favourable conservation status in designated areas—Special Areas of Conservation (SAC). The Birds Directive protects wild birds and their habitats within Europe, and has particular measures for migratory birds and those that are rare or endangered. It provides for Special Protection Areas (SPA) for wild bird habitats. A network of protected areas is being set up throughout the Community (Natura 2000 sites) which includes SACs and SPAs.

For new plans, projects, consents, licences and other legal permits, competent authorities are required to:

- Have regard for the requirements of the Habitats Directives when exercising any statutory function;
- Assess the impact on a site when considering undertaking work or granting permission(undertake an **appropriate assessment**);
- Proceed with the work or grant permission only when satisfied that the integrity of the site will not be compromised.

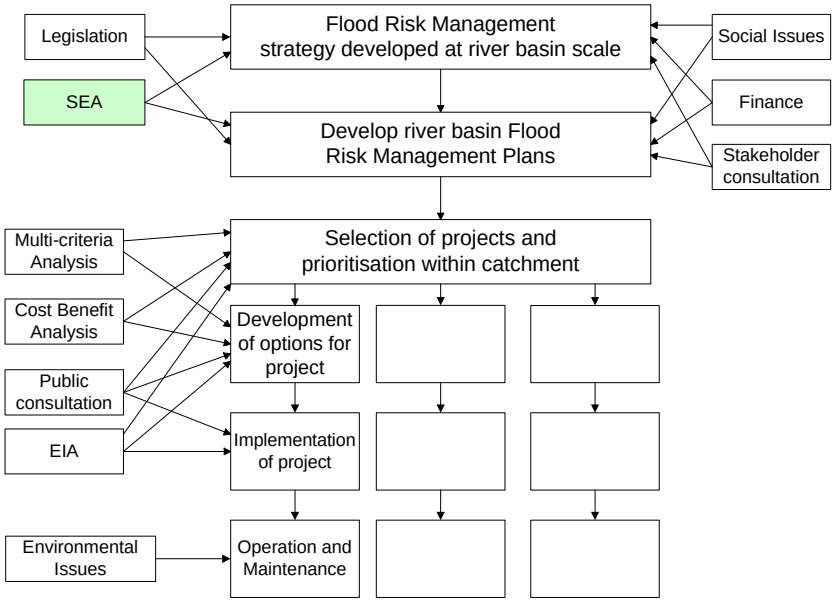
Site integrity concerns the coherence of its ecological structure so that it is able to sustain the habitats and species for which it is classified. An appropriate assessment (AA) is required when a plan or project, either alone or in combination with other plans or projects, could have a significant effect on a Natura 2000 site. The aim is to avoid adverse impacts, although in certain circumstances measures within the site to mitigate the impact are permitted. Works, which could affect the integrity of a site, can be allowed but only when there is an "over-riding public interest".

In such circumstances new habitat must be provided to compensate for that lost.

There has been much discussion recently over the stage at which appropriate assessments should be undertaken. The European Court of Justice recently held that although land use plans do not authorise development and planning permission must be obtained for development projects, they have great influence on development decisions and the sites concerned. Thus an appropriate assessment was required where there was a probability or risk that it will have a significant effect. The court held *"such a risk exists if it cannot be excluded on the basis of objective information that the plan or project will have a significant effect on the site concerned."* In doing so they have effectively lowered the threshold to be met as to when an appropriate assessment is required.

The main implications for FRM from the Habitats Directive is that the need for appropriate assessment and potential requirements for compensatory habitat will need to be considered as part of strategic plan formulation and options appraisal for flood risk management where they could affect a Natura 2000 site. Studies for FRM will need to identify Natura 2000 sites within a 5km radius or beyond that might be influenced by FRM activities. Consultation will have to be undertaken on the need for appropriate assessment and the scope of the assessment to be undertaken.

2.2.4 Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA)



European Directive 2001/42/EC (the SEA Directive) "on the assessment of the effects of certain plans and programmes on the environment" defines the SEA as a process designed to integrate environmental considerations into plans and programmes, thereby helping to protect the environment and to implement sustainable development.

The SEA process entails:

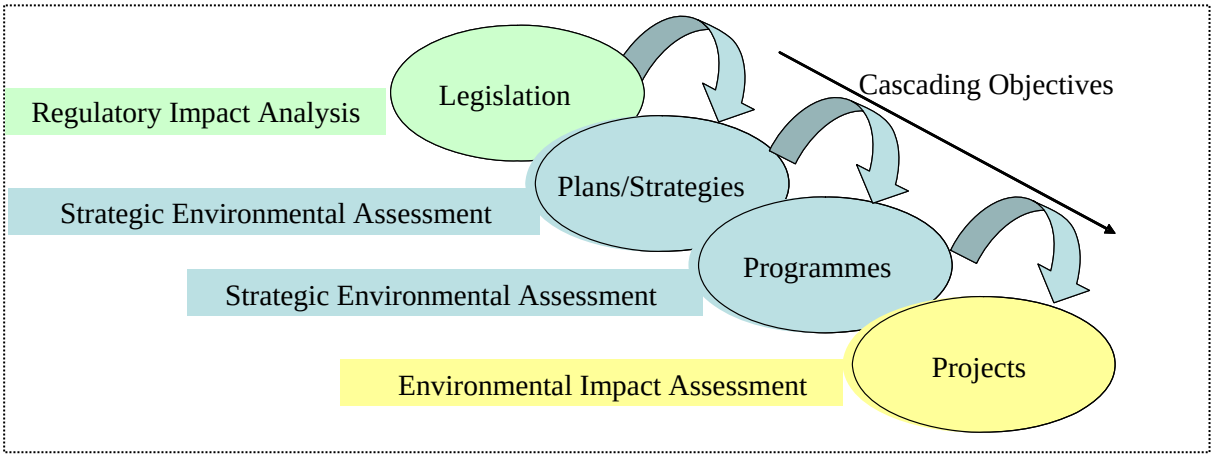
- assessing the likely significant environmental impacts of a plan/programme;
- preparing an Environmental Report;
- carrying out consultation;
- taking account of this consultation and the findings of the environmental report in decision making;
- providing information on the plan and how SEA results have been taken into account; and
- undertaking monitoring.

The 'SEA Directive', came into force within EC Member States in July 2004. It is a relatively new tool for many Member States, although in some countries environmental assessment has been used in resource and development planning for a number of years.

Environmental Impact Assessment (EIA) Directive (85/337/EEC as amended by 97/11/EC the assessment of the effects of projects on the environment) was introduced in 1985 and was amended in 1997. The EIA procedure ensures that environmental consequences of projects are identified and assessed before authorisation is given. The EIA Directive outlines which project categories shall be made subject to an EIA, which procedures shall be followed and the content of the assessment.

Directive 2003/35/EC providing for public participation and access to justice convention updated and clarified requirements for both the SEA and EIA directives, in line with the Aarhus Convention.

SEA and EIA follow a similar process, but SEA is carried out at a more strategic and higher planning level than EIA as illustrated in the diagram below.



Although EIA is a well established and an important tool for decision making on individual projects many of the important decisions will have already been made for example about the type of development that might be appropriate, its location and outline design.

SEA is required for plans, programmes and strategies that are formal plans identified under Member States' regulatory or administrative processes and meet the criteria set out in the directive.

River Basin Management Plans and Programmes of Measures prepared under the Water Framework Directive will require an environmental assessment under the Strategic Environmental Assessment Directive. There are a number of areas of overlap in the requirements of both Directives so there is scope to complete activities in parallel to reduce duplication of effort and resources. Appropriate 'signposting' within RBMPs will indicate how the requirements have been satisfied.

Flood risk management plans required under the Floods Directive will also require SEA once this directive is transposed into national legislation. It should be noted that for some Member States, national legislation or administrative processes may have already identify flood risk management plans as formal plans, making them eligible for SEA or they may have SEA legislation that is more inclusive than the SEA directive. In at least one case, the Member State recognises that although their FRMPs are not currently statutory plans and, therefore, SEA is not a formal requirement, it is undertaken as good practice to inform subsequent planning and project stages.

Certain plans and programmes including for national defence, civil emergencies, finance and budgets are excluded from the SEA Directive. This could include emergency plans following major flood events.

The SEA Directive explicitly refers to strategic assessment obligations arising under other legislation (Convention on Biological Diversity, UNECE SEA Protocol, EC Habitats Directive 92/43/EC) and the need to coordinate SEA requirements with assessment requirements arising from other European legislation, e.g. the Habitats Directive or the Water Framework Directive.

In addition to the levels of application, there are other key differences between the SEA and EIA Directives. In SEA, more emphasis is placed on the need to examine alternatives than in EIA. The overall consultation provisions of the SEA Directive are wider. There is also a requirement to take into account related policies and plans when developing objectives for the assessment. SEA requires a statement on how the SEA has influenced the plan or programme and also introduces the need for monitoring plan/programme implementation.

There are important benefits to be gained from SEA as well as reducing the risks of adverse environmental effects which might be associated with plans or programmes. Such effects are also

usually associated with economic and social costs, lost opportunities, wasted time and conflict. It is more efficient and effective to consider environmental issues at an appropriate time in the decision making process. For example, by the time an environmental impact assessment (EIA) is undertaken for a specific project, many of the important decisions will have already been made, for example, about the type of development that might be appropriate, its location and outline design.

Key benefits are that SEA:

- provides a framework for involving key stakeholders**,** including the public, in the development of a plan or programme - this ensures that those affected or with an interest have an opportunity to influence the plan/programme. In this way the SEA process can lead to plans/programmes which are more likely to address the issues and can help to reduce conflicts at more detailed stages.
- identifies environmental constraints and opportunities - which should influence how plan proposals are put together
- promotes the consideration of alternatives**:** SEA can help identify better environmental options - leading to better selection of plan/programme proposals
- allows cumulative impacts and benefits (i.e. combined effects of a number of different plan/programme proposals taken together) to be taken into account
- provides a framework for translating high level environmental policy objectives and targets into the plan process - and is, therefore, part of the process of implementing higher level policy direction
- can help to streamline environmental assessment for specific projects which implement the plan, thereby reducing the effort required, that is, for more local level or detailed plans or for specific projects particularly allowing 'tiering' of assessment through a hierarchy of plans. This is important for ensuring appropriate environmental considerations are taken into account at the right level

Overall the SEA process should:

- improve plans and programmes leading to measures or projects with reduced negative impacts on the environment and quality of life and can also help to ensure that they deliver enhancements and improvements.

The main implications of the SEA Directive for FRM, is that it is a formal process which will need to be incorporated into the development of those FRM plans/strategies that are a statutory requirement. Once the Floods Directive is transposed into national legislation this will include FRM plans for river basin districts. Beyond this there may be differences between countries in the level of FRM plans/strategies that are identified as statutory and in some countries SEA is undertaken as good practice for all FRM plans whether or not they are legally required.

2.2.5 Trans-boundary rivers including International and bilateral obligations

The main principle with trans-boundary rivers should be that no country should take any action which could compromise the ability of other countries to provide flood risk management unless the action is agreed between all parties involved. In dealing with trans-boundary rivers, it is advisable to have agreements covering all countries within a river basin. Failing this, bilateral agreements between adjoining countries may be effective.

In 1992 the Helsinki UNECE Convention on the protection and use of trans-boundary water courses and international lakes was formulated. This is directed primarily at water quality issues but it also includes references to floods. This can be used as a basis for agreements between countries that share a river basin.

The EC Floods Directive requires that for international river basins entirely with the EC either a single international flood risk management plan should be prepared for the basin or plans should be produced for individual territories but these should be coordinated, as far as possible, at the level of the international river basin.

Where an international river basin extends beyond the EC, the Floods Directive encourages the production of a single international flood risk management plan or, as far as possible, a set of flood risk management plans coordinated at the level of the international river basin.

2.3 NATIONAL LEGISLATION & PLANNING PROCEDURES

National legislation may be required to ensure that the authority responsible for Flood Risk Management has the powers to implement appropriate works and to prevent others from carrying out works that would adversely affect flood risk management. Thus national legislation should provide powers for the authority responsible for Flood Risk Management to:

a) promote works for the provision of Flood Risk Management
b) construct works for the provision of Flood Risk Management. This may include powers to acquire land on which to carry out works.
c) prevent the construction of or remove works that have been carried out by third-parties without permission that might interfere with Flood Risk Management
d) maintain and repair existing infrastructure related to flood risk management
e) take emergency actions during floods to protect life and property.

It is important to distinguish between ‘flood risk management’ and ‘flood prevention’. Flood prevention implies preventing floods from happening in the future. This is normally impractical to achieve as it is extremely expensive to provide protection against all future floods, however, extreme. Formally flood risk is the product of the probability of flooding and the resulting consequences. Flood risk management implies taking a whole range of measures to reduce flood risk by either reducing the probability of flooding or reducing the consequences of flooding or both.

In drafting legislation it is important to distinguish between ‘powers’ and ‘duties’ to provide flood risk management. The elimination of flooding is normally an impossible task that would be impractical to achieve but it is important and justifiable to use resources to control flood risk. Thus legislation should provide ‘powers’ to carry out work to mitigate flood risk but it is suggested that legislation should not impose a ‘duty’ to provide flood prevention.

It is suggested that governments should provide guidance to operating authorities on technical standards, environmental factors, project appraisal and post-project evaluation techniques. This will ensure uniform approaches are implemented nationwide that are consistent with the aims and priorities of the government. By specifying the nature of works that will attract government funding, it is possible to promote, for example, the use of soft engineering techniques. Specifying the use of economic criteria within project appraisal ensures that schemes which are implemented have a positive economic impact for the country.

A major developing issue is the potential future impact of climate change. The current climate change predictions suggest that there may be detectable changes in the climate over the next 50 to 100 years which may impact on flood risk management. As this is comparable with the engineering life of schemes that are presently being constructed it is important that schemes that are being designed and implemented now should take account of future potential climate change. The government is in a good position to recommend suitable allowances for future climate change and to ensure that these are taken into account when developing and appraising projects.

It is recommended that the government should set out a national policy on flood risk management for the benefit of operating authorities. The operating authorities can then produce plans for delivering these overall policy aims and objectives.

Planning procedures should enable proposed works to be subject to scrutiny to determine their potential impact on flood risk management. It is suggested that all planning applications that may potentially affect flood risk, for example, as they are located in a flood risk area, should explicitly contain an assessment of the impact of the proposed works on flood risk management. The potential impact on flood risk management should be one of the factors that is explicitly considered when deciding whether planning approval should be given. Planning procedures need to allow for public consultation and appeals. If the Planning authority is different from the Flood Risk Management authority then it is recommended that suitable arrangements are put in place to coordinate between these authorities.

It is recommended that the Planning authorities should prepare development plans which describe how national and regional planning policies are to be applied in the relevant area and to provide guidance on what particular types of development are to be allowed in particular locations. The control of land use in flood prone areas and the provision of flood risk management should be issues that are addressed within the planning system.

2.4 FINANCING FLOOD RISK MANAGEMENT (FRM)

2.4.1 Preliminaries

There is no "ideal" method of financing FRM, and a wide variety of practice is evident in EU member states. FRM is ultimately funded by citizens, either as taxpayers, property owners or water users, though member states can take advantage of external grants (e.g. EU structural funds) and loans (from EIB). Loans defer the cost burden to future generations, though loans on terms more favourable than the market contain a grant element.

One of the few basic principles that is universally valid is that FRM is an example of a "public good" - a service that has to be provided by public authorities, which is neither feasible nor profitable for private agents to supply. For this reason FRM is normally *implemented* by public bodies, who can *finance* themselves and recover costs in various ways, including charges levied on beneficiaries. Public bodies implementing FRM also need to compel private agents to comply with certain measures in the public interest, which shifts costs and the financing burden to the private sector.

Recalling the range of measures in a FRM menu (Table 2.1.), some naturally fall to public authorities to implement and finance (dams, river improvements, major embankments). Other measures (zoning, development regulations, building codes) displace costs – and financing - onto private developers and householders. Some of the latter types of costs are financial, others are "opportunity costs" in the form of benefits foregone. Compensation for flood damage and restitution of property and infrastructure is another, *ex post*, FRM measure, part of the cost of which can be shifted onto private individuals through insurance requirements.

Irrespective of how the initial capital costs of FRM are financed, subsequent costs can be recovered wholly or in part from beneficiaries and users (e.g. property taxes, development levies). Certain types of FRM have a high element of private benefits (e.g. flood-proofing individual buildings) which makes them eligible for private funding and implementation, with the possibility of public subsidy to cover any external social benefits.

2.4.2 Funding capital costs of FRM

The main sources are:

Central and local government budgets. (e.g. the UK's Environment Agency, which is responsible for FRM at national level, receives Flood Defence Grant-in-Aid from central government, supplemented by levies and grants from local government for schemes of local interest).
External grants (e.g. the EU Structural and Cohesion Funds)
Loans from EU or other regional sources (e.g. World Bank, EBRD, EIB or regional bodies such as the Black Sea Trade & Development Bank)
Loans from public financial intermediaries. (e.g. the Netherlands Water Boards are able to borrow on advantageous terms from the Dutch Water Bank, a publicly owned and guaranteed bank set up specifically to fund investment in water management).
Long term loans from government.

Costly items of public infrastructure are often funded using a blend of several types of finance. The art of "financial engineering" is to produce a funding package tailor-made for the project in question, reflecting the project's cash-flow profile, financial viability, physical and economic life, the balance of risks between the various parties, the division of benefits between private and public sponsors, the split of offshore and local costs, etc. In the EU it is often possible to "soften" financing terms by blending grant with loans.

Complex multi-purpose projects (e.g. combined power, water supply & flood control) may lend themselves to Private-Public Partnerships of various kinds, with risks allocated to the different stakeholders and finance from equity or loans on the balance sheets of the private partners. Guarantees from national (sovereign) or external agencies (EIB, EBRD) or private insurers (e.g. monoline insurance cos) may be taken up to enhance a borrower's creditworthiness. At a greater level of complexity, "structured finance" is another option. [6]

2.4.3 Recovering costs from beneficiaries, users & collateral sectors:

*Charges on water users. (*for example. the French *Agences de Bassin* fund their water resource management activities, including flood control, through surcharges on customers' water bills, sometimes referred to as a "polluters' tax").

Surcharge on property owners. (for example, the Netherlands Water Boards, responsible for surface water management including flood control, recover costs through charges on property owners).

Negotiated contributions from major individual beneficiaries (for example, large landowners, property developers, sporting complexes, factories, power stations)

Charges and fees for use of facilities and attractions. Certain assets created by FRM have recreational and tourism benefits which can form the basis of entry charges and fees to the general public, e.g. rambling, water sports on reservoirs, fishing & hunting rights, canal boating.

Cost sharing from multipurpose schemes. FRM is often one of the purposes of hydropower projects, river flow management, environmental preservation of wetlands, etc. Its costs can be shared with the budgets of these other sectors.

[6] Structured finance instruments can be defined through three key characteristics: (1) pooling of assets (either cash-based or synthetically created); (2) tranching of liabilities that are backed by the asset pool; (3) de-linking of the credit risk of the collateral asset pool from the credit risk of the originator, usually through use of a finite-lived, standalone special purpose vehicle (SPV).

Cost sharing in transboundary projects. FRM frequently entails transboundary projects, where costs can be shared with neighbouring countries or, where they are available, EU or other international funds for this purpose.

2.4.4 Insurance

In some countries householders and companies are able to take out insurance cover against flood damage. In some cases this is compulsory, or it is a condition of taking a mortgage loan. Flood risk may be a standard part of general household and property insurance, though in flood-prone areas it may be separately assessed, and attract a higher premium. In some countries, however, private insurance is not widespread, and householders look mainly to the state for compensation through the tax system. There are also examples of compulsory, state-run flood risk insurance schemes.

Recognising the variety of national practices, controversy tends to centre around a few issues:

- How to deal with flood victims that choose not to insure or are "too poor" to do so. This involves balancing the hardship of victims with the equitable treatment of those households that do bear the cost of their own insurance. It also entails the risk of "moral hazard": if the state acts in effect as the insurer of last resort, this discourages people from taking out their own policies.
- Policies towards building in flood-prone areas. In countries with limited development options (e.g. the UK) a significant proportion of existing properties are in areas of enhanced flood risk, and much of the planned new housing development is in such areas because of the cost and availability of land, and the relative ease of planning approvals. Should such householders pay the full cost of flood risk insurance? Should premiums be pooled between high and low flood risk areas (thereby amounting to a cross-subsidy from one to the other)? Should developers pay the insurance premia?
- What is the residual role of the state vis-à-vis private insurers. Should it act as reinsurer or ultimate guarantor for private insurance companies in difficulty (e.g. for events whose severity were not predicted)? Should it accept financial responsibility for public policies (e.g. towards housing development) that have placed some individuals at increased risk?
- If insurance is provided by the state or is pooled between high and low flood risk areas does this then lead to less effective control of development
- If insurance is entirely provided by private insurers is there then a risk that development control passes indirectly to the insurers.

2.4.5 Use of public subsidies to influence private behaviour

As noted above, part of the FRM armoury is the use of laws, regulations, penalties and inducements to persuade (or coerce) private agents to alter their behaviour. In such cases, the costs of FRM fall on private parties, though subsidies can be used to mitigate the financial burden.

The use of public subsidies could even be a more feasible and cost effective way of achieving FRM objectives, compared to measures involving full public sector implementation. Examples include:

> *Subsidies to farmers and landowners for catchment and watershed protection*, e.g. afforestation,
> *Reward for environmental stewardship* by farmers and landowners making changes to land use and farming methods, e.g. retention of hedges, tree cover, fallow areas).
> *Compensation for set-aside*, retention of waterside meadows, wetland restoration, etc.

Mandatory flood risk insurance can also be used not just as a method of mobilising funds but also a way of influencing public behaviour towards FRM. Where the full risk of flooding is factored into the

insurance premia paid by developers and householders, less development is likely to occur in flood-risk areas, than in situations where such risk is not fully monetised.

Taxes and property surcharges can also be used to penalise inappropriate development in flood-risk areas, or other practices (e.g. building features) not in keeping with FRM.

3. Flood Risk Management Practice within Europe

3.1 INTRODUCTION

While the philosophy behind FRM has been virtually universally adopted across Europe, as, for example, illustrated by the adoption of the Floods Directive, the implementation varies within different countries. This variation arises from a number of sources;

a) the nature of the flood risk is different in different countries
b) the nature and quality of data that is available varies
c) social attitudes vary between countries
d) the concepts and methods of FRM are rapidly developing and their degree of implementation varies.

A review of the practices within Europe showed that within Europe the institutional arrangements in the different countries vary widely. It would appear that political and historical considerations outweigh any concerns for rationality or efficiency.

It should be noted that the nature of the flooding problem varies widely throughout Europe. All locations in all countries can potentially be vulnerable to local inadequate drainage and so are potentially at risk from rapid, localised flooding. In some countries flood risk is predominantly associated with large rivers which rise slowly and for which some form of warning can be given. Some countries contain small, steep catchments in which there is a risk of extreme and rapid flooding. In such locations conventional flood warning may not be feasible. In some of these small, steep catchments significant sediment loads can be carried by a flood so that either real or pseudo debris flows develop. These make assessing the flood risk more uncertain and also can increase the potential for loss of life.

3.2 INTEGRATED RIVER BASIN APPROACH

An integrated river basin approach is central to the present philosophy of FRM and has been universally adopted. Such an approach has only really become practical with the advent of powerful computer models that can be applied to whole catchments. In applying such models there are differences within Europe depending upon the different availability and experience of numerical models and the availability of the necessary detailed data. Some of the older EU Member States have longer experience in this area than some of the newer Members. In some countries detailed remote-sensing topographic data is available in the form of Digital Terrain Models. These can be used, for example, to carry out national assessments of flood risk.

3.3 PRIORITISATION AND SELECTION OF PROJECTS

The methods used to prioritise and select projects differs in different countries. The selection and prioritisation of schemes is usually carried out using some form of multi-criteria analysis. In most countries some form of economic assessment plays an important role but there is no general agreement as to what additional factors should be included in the analysis and what weight should be attached to them.

A major component of such an analysis is some form of economic assessment, such as cost/benefit analysis (CBA). The nature of the flood risk in The Netherlands, however, leads to a different approach in that country. As much of the country and the major infrastructure are potentially vulnerable to flooding, conventional CBA would justify almost any standard of defence. As a result standards of defence are defined in primary legislation. In most other countries flood risk management

is justified by some form of CBA. The implementation of CBA differs between countries, mostly as a result of the different availability of data. In some countries, such as the UK, detailed flood damage data and spatial property data are available which allows the easy estimation of detailed damage costs for different scenarios. Catchment flood management Decision Support software is also available in some countries, such as the UK, which eases the handling of such detailed spatial data. Certain other Member States do not yet have detailed flood damage data. This means that simpler approaches to estimating damage costs have to be adopted. Though the use of some form of economic analysis is virtually universal, there is no common agreement as to how such an analysis should be carried out.

3.4 INSURANCE

The use of insurance as a method for both mitigating the impacts of flooding and encouraging the reduction of the susceptibility to flood damage varies widely. There are differences between countries in their social attitudes and recent histories which affect their approaches to insurance. In the French model a compulsory charge is levied on all house and car insurance premiums. The money from this goes to a Fund for Natural Hazards which is kept by the insurance companies. If an exceptional flood occurs the local authorities can request funding and, if this is accepted, then the insurance companies cover the damages. If the money held is insufficient then the Government pays the rest. This spreads the cost of flood damages over the whole population but may diminish incentives to reduce exposure to flood risk.

In the UK flood insurance for homeowners and businesses is provided by the private insurance industry, while the cost of emergency services and damage to public property is covered either by local or central government. Until recently there was an agreement between the insurance companies and the government not to charge differential premiums for properties at risk of flooding. This agreement lapsed recently and so insurance for properties which flood frequently may become expensive or, in some cases, impossible to obtain.

3.5 PUBLIC AWARENESS AND PARTICIPATION

Practice in relation to public consultation and participation in all European countries should now be converging on that described in the EIA and SEA Directives. The detail and accuracy of flood risk information that is made publicly available varies throughout Europe though with the implementation of the Floods Directive it is expected that practice throughout Europe will converge.

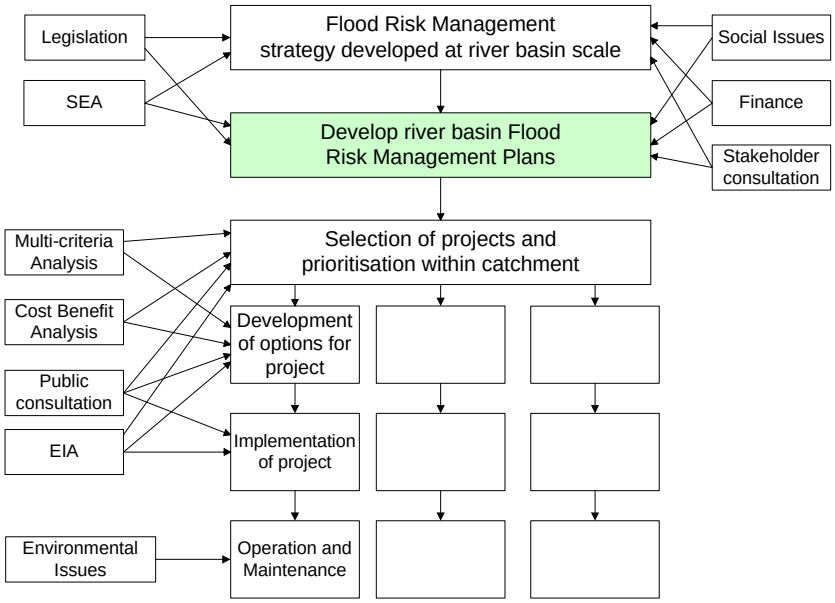
3.6 LAND USE CONTROL

In most European countries land use planning is in the control of local authorities. Though flood risk is a major factor in deciding land use, it is frequently not the only factor and development pressures may lead to development in flood risk areas. The level of guidance given by central government to local authorities varies. If developments are subsequently flooded there is normally no method of obtaining redress from the local authority. This can often lead to lax implementation of planning controls. In Norway, however, the local authority may be liable if it has permitted development in an area which is subsequently subject to flooding. It is claimed that this increases risk awareness and promotes better land-use practice.

3.7 FLOOD EMERGENCY ACTIONS

The organisation of flood emergency response differs widely throughout Europe and this arises as the organisation of the bureaucratic responsibilities for flood emergency response very widely. All European countries do have some formal structure to ensure both local and national response to flood emergencies.

4. Flood Risk Management within a river basin context



4.1 FLOOD RISK ASSESSMENTS, MODELLING, DATA COLLECTION, FLOOD RISK MAPPING, ALLOWANCE FOR CLIMATE CHANGE

Assessments should be made of the flood risk under present conditions. This should establish the areas that are liable to flooding for events with selected probabilities and the characteristics of that flooding in terms of depth of flooding and flow velocities. This can be based on historic data or on some form of modelling.

The nature of the modelling undertaken should be appropriate to the nature of the problem being addressed. Thus the modelling required to produce national flood risk maps may be less detailed and less accurate than the methods used to predict the impact of a specific flood relief scheme.

Any assessment of flood risk requires hydrological data, which should be the subject of a programme of flow data collection, archiving and analysis. There should be recognised hydrological methods that can be used in a country or region. These may be based on local data or may be general methods.

Modelling requires detailed topographic and bathymetric data. This data should be collected as required. It should be noted that methods of data collection are changing rapidly, particularly as a result of the development of remote sensing techniques.

Modelling can be used to determine, for example:

a) flood prone areas,
b) potential depth of flooding,
c) duration of flooding and
d) speed of rise of flood waters.

Modelling can also be used to investigate risk and the residual risk associated with floods which exceed in magnitude those for which defences are provided. It is also possible for models to take into account the probability of failure of individual flood defences and to assign flood risk to individual

flood defence elements. This can provide valuable information to prioritise potential works to reduce flood risk.

Flood risk management requires a knowledge of:

a) the probability of flooding and
b) the consequences of flooding

The probability of flooding may be derived from a number of different sources. It may be derived directly from historic data on water levels or it may be derived indirectly from modelling. In both cases some form of historic data is needed. If modelling is used then the historic data can be rainfall or river flow. The length of the available record is important in assessing the magnitude of events with small probabilities. Thus it is important to collect data routinely on both rainfall and river flow.

If a sufficiently long length of record is available then it is possible to estimate the magnitude of floods with different probabilities directly from an historic record. Such historic data cannot be used to assess the impact of proposed works so if this is required then some form of modelling would have to be undertaken.

The nature of the model and the corresponding data requirements depends upon the purpose of the modelling and complexity of the system to be modelled. The following data would probably be required for any modelling study:

Hydrological data on rainfall and/or river flows
Channel bathymetry data as required
Data on flood defences
Data on hydraulic structures
Topography of floodplains

Recent advances in remote sensing techniques means that some of this data, for example, floodplain topography can be collected remotely. This has significantly reduced the cost of data collection and has made feasible the application of models to regions or nationally.

Modelling can be used to determine flood risk. Numerical models can be used to estimate the severity of flooding in terms of flooded areas, depth of flooding and duration. Models should normally be able to provide information on flow velocities. When combined with estimates of flow depth, these can be used to assess the hazard to people.

Information on flooded areas can be used to assess populations and assets at risk. The most appropriate methods to use depends upon the detail that is required and the data that is available.

The assessment of regional or national flood risk is made easier if the following types of data are available:

a) digital terrain model with a suitable grid size
b) data on flood defences
c) data on properties and population distribution

In addition to assessing the present flood risk, it is advisable if an assessment is made of how the flood risk might change in the future as a result of potential future climate change. In the past the estimate of the magnitude of floods with a specified probability has been based on analysing historic data. The use of historic data implicitly assumes that the overall climate is constant and the variation from hour

to hour, day to day, month to month or year to year is due to random fluctuations. In statistical terms the climate was regarded as a stationary process.

It is now becoming apparent that changes in the atmospheric circulation and in the dynamics of the atmospheric and ocean systems mean that the probability of events can change through time. Systems such as the North Atlantic Oscillation can affect the probability of climatic events. In addition it would appear that long-term climate change is taking place. In these circumstances it may not be adequate to rely purely on historic data to predict probabilities in the future. This is of particular concern to engineers who are designing structures which may have design lives of the order of 100 years.

There are global and regional climate models that are being used to predict potential future climate change but these are subject to significant uncertainties. These models are frequently coarse in scale and the downscaling of results to determine the implications for local climates adds another layer of uncertainty.

Some regulators in Europe are currently making pragmatic allowances for climate change, for example, by increasing estimated peak discharges of a given probability by 20%. While this may be a short-term expedient, it is likely that better and more justifiable estimates of future climate trends should be available soon and the most appropriate, reliable methods of estimating future potential climate change should be adopted as these become available.

4.2 STRUCTURAL AND NON-STRUCTURAL MEASURES

The use of non-structural measures may be cheaper and more sustainable than the use of structures. Non-structural measures may be used to increase the volume of storage and hence flood peak attenuation in the system. Non-structural measures that may be considered include:

a) the creation or restoration of wetlands or flood storage areas,
b) the setting back of existing flood banks away from the river to increase the area of floodplain available for flooding
c) the restoration of natural river systems in which natural floodplains are fully utilised during flood events
d) spatial planning to control development in flood prone areas
e) provision of insurance
f) public education and awareness
g) preparation of emergency plans.

In considering such measures it must be remembered that their impact may extend over considerable parts of the river system and so it may be possible to implement measures at locations that are some distance away from the location of existing flooding problems.

Box 3 Room for Rivers policy

Due to climatic changes it is anticipated that the Rhine delta river branches will have to accommodate ever-higher extreme discharges. Until recently it was standard policy to raise the crest levels of the flood dikes to maintain the required level of flood protection. This centuries old policy was abandoned in the year 2000 in favour of a new policy entitled ‘Room for the River’. Under the new policy, discharge capacity is increased by setting the flood dikes further away from the river, or by lowering the land in front of them. This will result in lower flood levels. Under the ‘Room for the River’ policy care is taken not to affect valuable features of the landscape, nature or cultural history. The aim is to provide a balance between the present and foreseeable future spatial requirements, while taking every opportunity to enhance safety and improve the overall environmental conditions.

In some rivers urbanisation may have the potential to increase flood risk downstream. Such a potential increase may be reduced or removed by the use of infiltration drainage systems (often referred to as Sustainable Drainage Systems (SDS)).

Where structural measures are used then the residual risk of flooding should be assessed and appropriate precautions taken as necessary, such as the provision of flood warning. The recent development of demountable flood defences has meant that urban areas where there is limited available space can be protected.

Box 4 Flood Risk Management within a major city

In December 1993 the centre of a major European city was flooded resulting in damages estimated at €75 million. This was the first major flood since 1926 and so flood management was weak. In 1995 a flood similar in magnitude to the 1993 flood occurred but the damage was approximately €32 million, that is, 40% of that for the 1993 flood. The reduced flood damage was attributed to:

a) improved emergency management
b) extensive emergency measures put in place during the event. The effort was estimated at 125,000 man hours and
c) deployment of 1,400 m of demountable flood barriers
d) use of 400,000 sand bags for local protection.

Following the 1995 floods the City Council has implemented further measures to reduce flood risk which concentrate on water retention upstream, reduction of potential damage within the city and flood awareness and preparedness of the inhabitants.

This demonstrates how a combination of flood risk management strategies can be deployed to reduce flood risk and how lessons learnt during flood events can be used to reduce future flood risk further.

4.3 FLOOD FORECASTING AND FLOOD WARNING

Where flood prevention is not appropriate, the risk to life and property from flooding may be reduced by providing flood warning. Effective flood warning relies upon:

a) flood detection
b) flood forecasting
c) dissemination of flood warnings
d) action by those potentially at risk and by civil protection agencies.

Appropriate methods will depend upon the nature of the catchment, the local information systems and potential routes for dissemination. The operation of hydraulic structures should be integrated into any flood forecasting system. For international rivers particular attention should be paid to harmonising procedures, and the storage and exchange of data between neighbouring countries.

Flood forecasting requires an understanding of the meteorological and hydrological conditions, and is, therefore, the responsibility of the appropriate government agencies. National organisation is required, but information needs to be made available at a river basin scale. This allows forecasting to integrate with flood warning arrangements. To examine the capability for flood forecasting, the following should be investigated.

- What are the arrangements for flood forecasting, and what government services are involved?
- Is the flood forecasting operation linked to surrounding countries, especially where shared river basins are concerned?

- Does the meteorological service have access to international data and forecasts, weather satellite and weather radar information?
- What is the status of the hydrometric network (rain gauges and water level), that could be used in a forecasting system?

After reviewing the above, a needs assessment should be conducted to establish what is required to provide a real time flood forecasting system. This essentially requires:

- Establishment of a network of manual or automatic hydrometric stations, linked to a central control by radio or telemetry;
- Flood forecasting model software, linked to the observing network, and operating in real time.

To be effective the modelling software has to be designed and calibrated through a period of hydrological monitoring and study. The system requires regular performance review and re-calibration, so as well as capital costs, the recurrent costs for operation and maintenance of the system need to be taken into account.

The main components of a national flood forecasting and warning system are as follows:

1. Collection of real-time data and prediction of flood severity and time of onset of particular levels of flooding;
2. Preparation of warning messages describing what is happening, predictions of what will happen and expected impact. Messages can also include what action should be taken;
3. The communication and dissemination of such messages;
4. Interpretation of the predictions and other flood information to determine flood impacts on communities;
5. Response to the warnings by the agencies involved and communities;
6. Reviews of the warning system and improvements to the system after flood events.

These components are shown in Figure 4.1. For a flood warning system to work effectively, these components must all be present and they must be integrated rather than operating in isolation from each other.

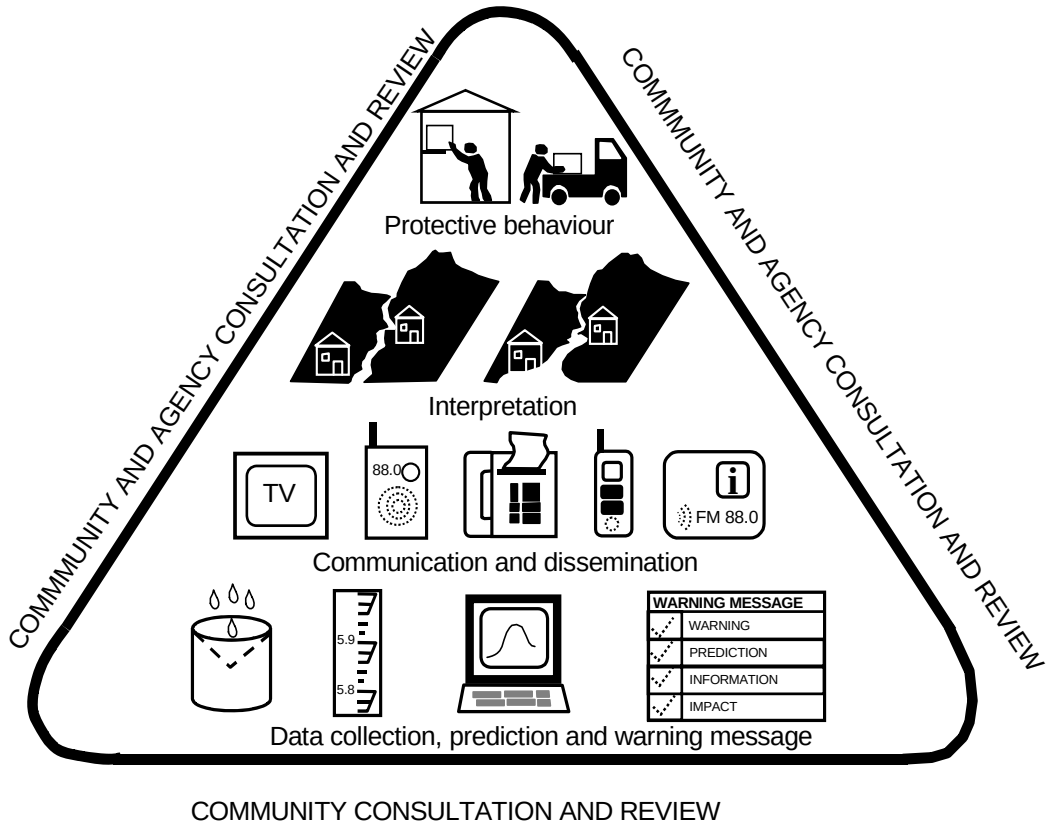


Figure 4.1 The main elements of a flood forecasting and warning system

Box 5 Provision of flood forecasting to reduce risk to life and property

A major Asian city was subject to flooding in 2002. There was little prior warning of the flooding and it resulted in a number of deaths and significant damages. Following the flood a flood warning system was installed. In 2006 the city was subject to a flood of a similar magnitude as that experienced in 2002. The flood forecasting system provided 7 days warning of the event and the warning initiated controlled flooding of land upstream of the city. As a result there were no deaths and the damage was minimal.

4.4 LAND USE, ZONING AND PLANNING

Flood risk can be effectively reduced if, in addition to technical measures, spatial planning regulates land-use in flood-prone areas. Sustainable spatial planning should be based on promoting building development outside of the flood-prone area as often as possible, avoiding or stopping building development on flood plains (land-use control) and developing appropriate building codes or zoning ordinances to reduce flood damage.

An excellent way of limiting future increases in the potential for future increases in flood damage is to prevent development on flood-prone lands with appropriate instruments of spatial planning. Alternative uses of flood-prone land other than building should be considered where possible. There are benefits to having flood prone land zoned and its use restricted to uses such as parks, nature areas or ecological reserves.

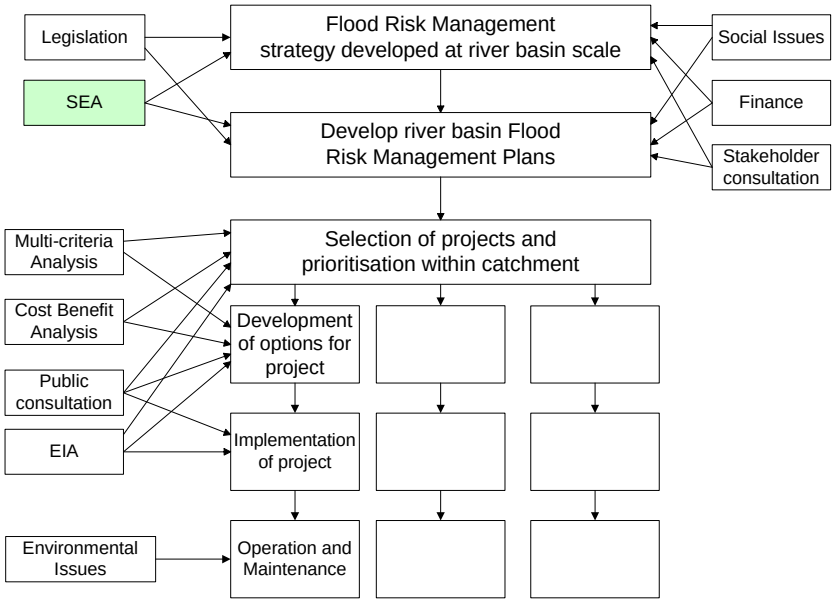
4.5 FLOOD RESILIENCE OF BUILDINGS

New or existing buildings in flood risk areas can be made more resilient to flooding by the use of appropriate building materials and methods of construction. This means that, when the building is flooded, damage is reduced and the repair is quicker and less costly than would otherwise be the case.

Box 6 Flood resilience of buildings

A national association of insurers has carried out studies that have shown that the cost of flood damage to buildings can be significantly reduced by using methods and materials that are resilient to flooding. Where buildings have been damaged by flooding there may be long-term benefits if the repairs to those buildings incorporate such flood resilient methods or materials

4.6 STRATEGIC ENVIRONMENTAL ASSESSMENTS



Neither the EC SEA Directive nor the Kiev SEA Protocol prescribes who should organize and carry out the SEA but normally it is the responsibility of the authority which prepares and/or adopts the plan or programme. It is most likely to be effectively undertaken by a team able to:

- Understand the issues related to the subject of the plan or programme
- Evaluate the full range of environmental issues
- Take a balanced and objective view
- Consider and respond to local circumstances
- Have some experience of consultation approaches and can draw on good practice from elsewhere.

Good practice in SEA emphasises the value of integrating the assessment with the plan or programme making process. Many benefits of SEA may be lost if it is carried out as a completely separate process. It is helpful to involve the following groups:

- those producing the plan/programme in the SEA,
- those who will be responsible for implementing the plan/programme,
- others either within the authority or outside, who can contribute expertise or a detached and independent view.

The legal requirement for SEA under the EC SEA Directive, is a relatively new tool for many Member States, although in some countries environmental assessment has been used in resource and development planning for a number of years. The SEA directive was adopted in 2001 and came into force within EC Member States in July 2004. This means that while a body of practice in SEA has been built-up, experience in applying the specific requirements of the Directive is still emerging. The key steps in the SEA process to be followed are:

A. Scoping

- Setting the context including a policy and plan review
- Establishing the baseline and identifying issues
- Setting objectives
- Developing alternatives /identifying options
- Identifying issues
- Developing a framework for the assessment
- Consulting on and deciding the scope

B. Assessment

- Comparing environmental effects of alternatives/options
- Selecting alternatives/options
- Consulting on options/alternatives (advisable but not mandatory)
- Assessing the effect of the plan/programme
- Identifying mitigation required to avoid reduce or compensate for adverse effects
- Identifying monitoring requirements

C. Preparing the Environmental Report

- Documenting the scoping and assessment process and findings and meeting minimum information requirements set out in the Directive.

D. Consultation and public participation on the draft plan and Environmental Report

- Identifying statutory consultees and other stakeholders/ interested parties
- Undertaking consultation at Scoping with Statutory consultees and also with the public at draft plan stage as a minimum requirement

E. Decision making and adoption

- Information on decision and access to the plan and Environmental Report
- Statement of how Environmental Report and consultation have been taken into account in the final plan and programme

F. Undertake monitoring

- Monitor potential significant effects on environment, comparing the alternatives

The EC SEA Directive requires an assessment of significant environmental effects on the issues listed in the table below. The scoping stage should have determined which of these need to covered.

Environmental issues from SEADirective:

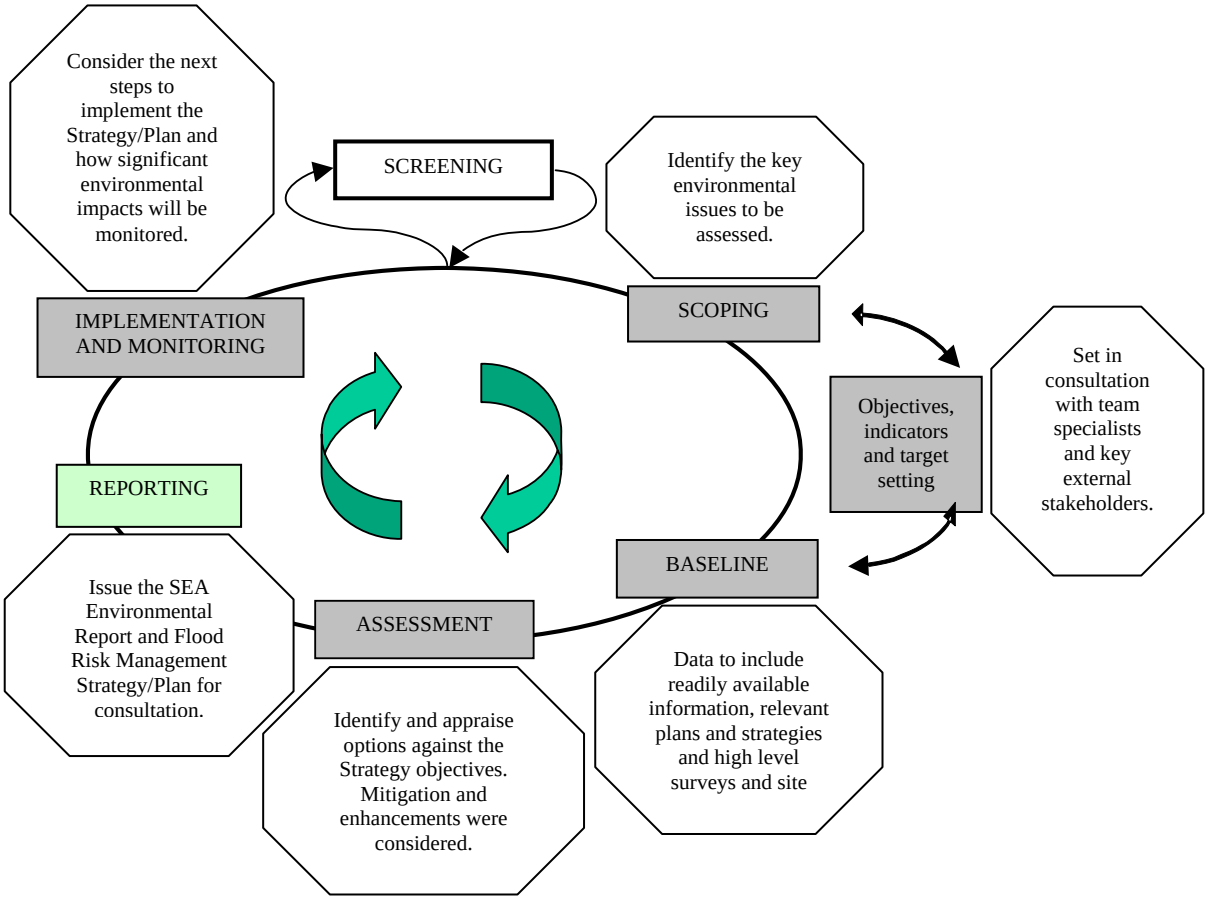
- biodiversity, fauna and flora;
- population and human health;
- soil;
- water;
- air and climatic factors;
- material assets –e.g. infrastructure, property;
- cultural heritage, including architectural and archaeological heritage;
- landscape.

Other related environmental/sustainability concerns to be included:

- energy efficiency;
- use of renewable and non-renewable resources;
- vulnerability or adaptation to climate change;
- waste management;
- transport demands, accessibility and mobility, etc.;
- social/community effects on social equity and vulnerable groups;
- socio/economic aspects.

Consideration of effects should include secondary, cumulative, synergistic, short, medium long term, permanent, temporary, positive and negative effects.

An outline of how the SEA process can be integrated with FRM is set out below:



A key part of SEA is setting the objectives against which alternative options/approaches will be assessed. These can be derived from high level objectives and the review of plans and policies and an

understanding of the key environmental issues for the study area. The approach generally aims to take account of sustainable development, and the need to adapt to climate change and involve stakeholders, to reduce the threat to people and their property, and deliver the greatest environmental, social and economic benefit.

An example of a set of objectives developed for a FRM strategy is given below.

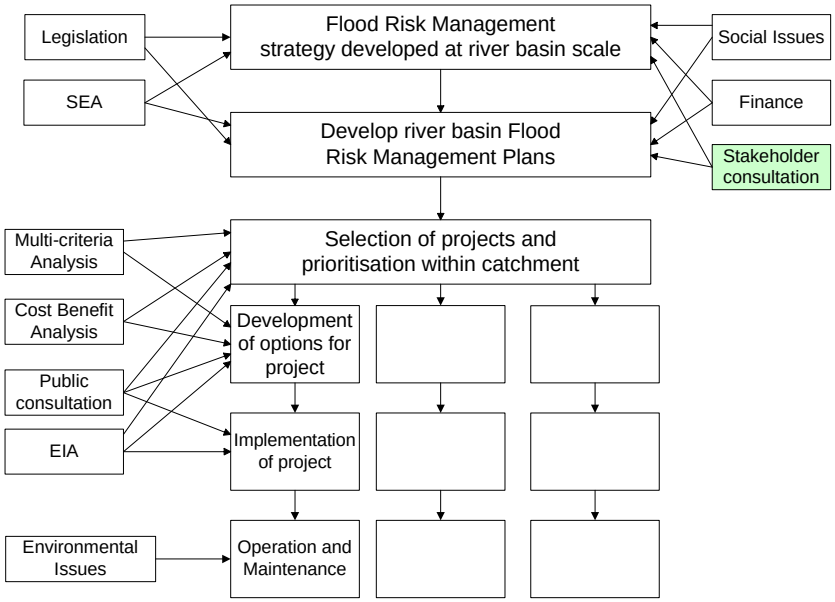
Strategy Objectives

- Identify a **framework for sustainable flood risk management** providing technically feasible solutions to reduce flood risk to property and infrastructure, by:
  - Developing sustainable solutions to flooding problems that work with natural processes.
  - Ensuring that flood risk management solutions consider climate change.
  - Promoting rural and urban land management as part of the flood risk management solution including soil management by farmers and controlling development in urban areas and promoting sustainable drainage systems.
- Identify measures to maximise environmental and social opportunities by:
  - Identifying opportunities where we can make significant positive quality of life improvements, particularly through regeneration initiatives.
  - Developing solutions that take account of landscape character and, where possible, make a contribution to the reinforcement of that character.
  - Improving access and recreational opportunities within the catchment/ River corridor.
  - Protecting and enhancing the historic environment,.
  - Developing solutions that take into account Biodiversity Action Plan objectives with the aim of creating a net improvement in wildlife value and enhance the catchment/River corridor.
  - Enhancing fish migration through the catchment.
  - Ensuring that water resources and quality are maintained or improved.
  - Developing a solution, which, through innovative design, uses resources efficiently, and through re-use and recycling, minimises waste going to landfill.
  - Reducing carbon emissions and promoting the use of renewable energy on the project.
- Develop a solution that is **safe** for both the public and operators.
- Provide a **plan of investment** for flood risk management for the long term which is economically viable and takes in to account the whole life cost.

(adapted from Environment Agency's Derby FRM Strategy SEA Environmental Report)

These objectives can be simply be integrated with other FRM objectives for example related to cost effectiveness, flood protection benefit, technical feasibility and considered together as part of strategy/plan option appraisal.

4.7 PUBLIC AWARENESS, CONSULTATION AND PARTICIPATION



The Water Framework, Floods, SEA and Habitats Directives all include requirements for providing public information and for consultation with stakeholders.

The WFD under article 14 makes public consultation essential during the production, review and updating of river basin management plans which form the central theme of the Directive. It is also recognised that for public consultation to be meaningful people will need a basic understanding of the principal features of the Directive and how these relate to the situation in their own local river basin.

The Floods Directive requires that FRM plans are coordinated with River basin management plans. It also specifies the information to be made available to the public as the, preliminary flood risk assessment, the flood hazard maps, the flood risk maps and the flood risk management plans. It also requires Member States to encourage active involvement of interested parties in the production, review and updating of the flood risk management plans.

The Habitats directive requires consultation in relation to potential impacts on European Designated sites and appropriate assessment.

In general, for the development of a FRM plan, SEA is likely to be required. The consultation requirements are more specifically defined in SEA Directive and FRM consultation can usually best be met in parallel with those set out for SEA and through coordination with the RBM process. The SEA Directive requires consultation with specified stakeholders and the public affected or likely to be affected by, or having an interest in, the plan/programme. This includes relevant non-governmental organisations, such as those promoting environmental protection and other concerned organisations. As a minimum it requires consultation on scoping the assessment with the statutory consultees and also with the wider public on the draft plan and the accompanying Environmental Report. Additional consultation with the concerned public/ groups is recommended. This does not need to complicate the procedures, but can usually benefit both the plan and help the processes in the long run. It is common practice to publish a scoping document or early draft of the Environmental Report as a means for consultation with key stakeholders and to make this available to the public as well.

Key actions that should be undertaken on consultation for FRM and SEA:

- Identify those organisations where consultation is required under the legislation at key stages
- Identify key stakeholders likely to have an interest
  e.g. Other authorities for neighbouring areas or within area, higher level authorities, ministries, institutes, agencies, business groups, local interest or community groups,
- Identify potentially affected and interested public.

Sections or areas of the community likely to be affected by the plan/programme proposals should be identified and specific action taken to inform and consult with them. A communication plan can be a useful tool to help clarify the approach, list consultees, track consultation response and the resulting proposals for the plan or assessment.

Undertaking consultation and encouraging public participation

In general, for stakeholders and public to comment they need first to be made aware of the plan/programme process, how to get access to the relevant documentation and also to understand how they can respond. Example of ways of communicating with stakeholders and public include:

- Information about the preparation of a plan /document and SEA process can be placed in national and regional newspapers, in a publicly accessible place (e.g. in the premises of the administration or public libraries), and/or on the websites of the programming authority and/or relevant environmental authorities. Newspaper articles and radio broadcasts are also good ways of raising awareness.
- Sending out letters – usually to a list of consultees
- Dedicated webpage may be established to inform stakeholders, collect feedback, and enable the participation of stakeholders in drafting and/or commenting.
- Public hearings - formal public hearings which are frequently used in project-level environmental impact assessment (EIA) can be costly, potentially overly legalistic and may not provide the most effective means for consultation within a plan or SEA process although they are used in some countries.
- Workshops –a popular and flexible means of engaging groups, encouraging participation in a less formal atmosphere.

Since plan strategies are higher level and can involve more complex process, the key to successful consultations is to generate awareness and engage the participants in consideration of choices that need to be made. Such consultations are usually best through facilitated workshops or conferences.
Other appropriate tools for soliciting feedback include:

- dedicated email addresses or hotlines for collecting comments;
- public exhibitions – small mobile exhibitions are particularly useful where a number of different locations need to be covered;
- consultative groups comprising representatives of relevant environmental authorities and the concerned public.

The choice of appropriate tools depends on the time available, the nature of the issues for review and the complexity of the documents to be consulted.

The Directives generally do not specify a particular mechanism for public consultations. The SEA Directive, for example, only stipulates that the public needs to be "given an early and effective opportunity within appropriate time frames to express their opinion". When arranging consultations, the authorities should keep in mind that consultations for plans may differ significantly from project-level consultations, which often raise considerable public interest. This may be because they appear more remote to individual interests but also possibly because of lack of awareness and insufficient understanding of the issues and the potential to influence outcomes.

Responses are often confined to well-organised groups that have a strong interest in the process (e.g. major NGOs, think-tanks, associations of municipalities, chambers of commerce). The approach to consultation and choice of techniques should take this into account.

A summary of the stages and timing of consultation is provided in the table below.

Table 4.1 Stages in Consultation

Plan Step	Consultation mandatory	Good Practice
Screening	Statutory consultees - Decision made available to public	
Scope and level of assessment	Statutory consultees	Other key consultees and public –
Assessment		Key consultees (including public as appropriate) - may be an iterative process of assessment and modification and reassessment
Environmental Report and Draft Plan/Programme	Make Plan/Programme and ER available to the public Consult with Key Consultees and Public	
Finalisation of plan	Respond to comments and produce statement on how SEA and responses to consultation have influenced the plan	
Adopted plan/programme	Information to consultees and public	

4.8 STRATEGIC LEVEL OPTION, APPRAISAL AND SELECTION

Where there are a number of possible options that have been identified to address some identified flooding problem, then the differences between the environmental impact of these options is likely to be significantly greater than the differences between different versions of the same option. For example, if a particular flooding problem can be addressed by either providing additional floodplain storage upstream or by providing flood embankments then the broad differences in environmental impact between these two solutions is likely to be greater than the differences between, say, different ways of constructing and configuring the flood embankments. Thus to reduce environmental impact or even to enhance the environment it is important that as wide a range of possible options are considered both at the strategic planning level and at the project level.

The requirement to consider as wide a range of feasible options as possible is not one that can be imposed by legislation or regulation. It can be encouraged, however, by the availability of information relating to the potential methods of flood risk management and the use of 'soft' engineering. Whilst logical rules can be used to establish the appropriate baseline option, it is much less easy to provide rules hat will ensure that the 'best' option is amongst those considered. All that can probably be done is to provide guidance on what options should not be excluded prematurely. One approach to avoiding premature closure of the range of solutions being considered is to ensure wide consultation with groups that have disparate views. Within the processes used there should be the freedom for new options to emerge, often consisting of combinations of different elements of other options. Consideration of the widest range of options can also be encouraged by any permitting authorities. In the UK the then Ministry of Agriculture, Forestry and Food recommended that the minimum set of options that should be compared should include:

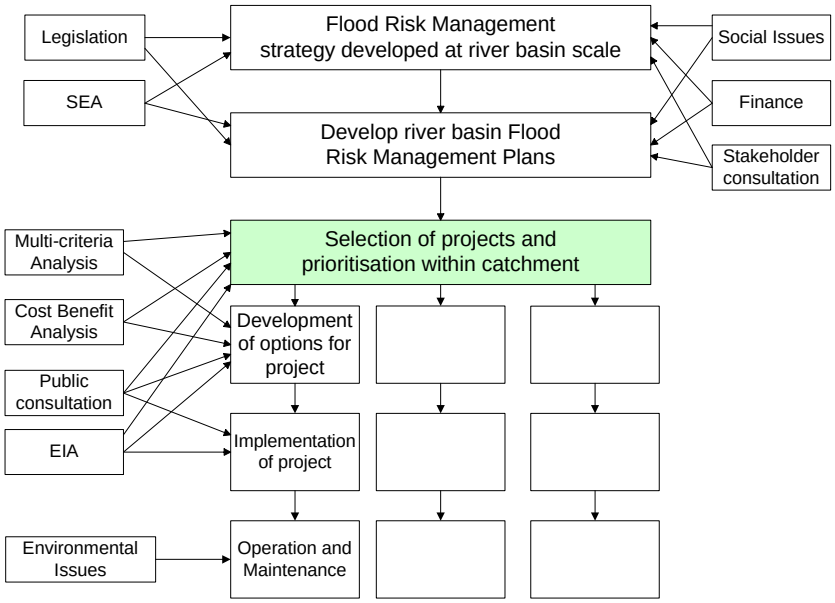
- Managed retreat/ managed realignment of defence line
- Different standards of protection
- Alternative timing of works

- Different approaches to solution of the problem
- Options suggested by consultees
- Local protection of areas of high value (including floor-raising and flood-proofing)
- Best environmental option.

Most of the environmental impact is determined once the option for a scheme has been selected. In general the scope for including environmental improvements within an option is limited and the main difference in environmental impact is determined by option selection. This emphasises the central role of using Strategic River Basin Management Plans to ensure that the best environmental options are developed.

The selection of environmentally friendly options can be encouraged by methods used for the selection of the preferred option. A method that relies solely on economic indicators, such as, cost-benefit analysis, may not result in the selection of an option which ensures environmental acceptability. The explicit inclusion of environmental factors in the selection of an option puts greater emphasis on the environment. There is no consensus within Europe, however, on how options should be selected and the weight that should be placed on economic and non-economic factors.

5. Selection of projects: choice, prioritisation & appraisal



5.1 PROJECTS AND STRATEGY: THE BROADER PICTURE

Whatever projects are selected should be part of a coherent national strategy of flood risk management, as outlined in Section 2 above. The balance between projects of different types (e.g. structural & non-structural measures, upstream& downstream projects) will, to a large extent, be dictated by strategic considerations, and will result from river basin management plans, and related modelling exercises. Individual schemes can then be filtered and ranked using project appraisal criteria, such as cost-benefit analysis (CBA) and multi criteria analysis (MCA).

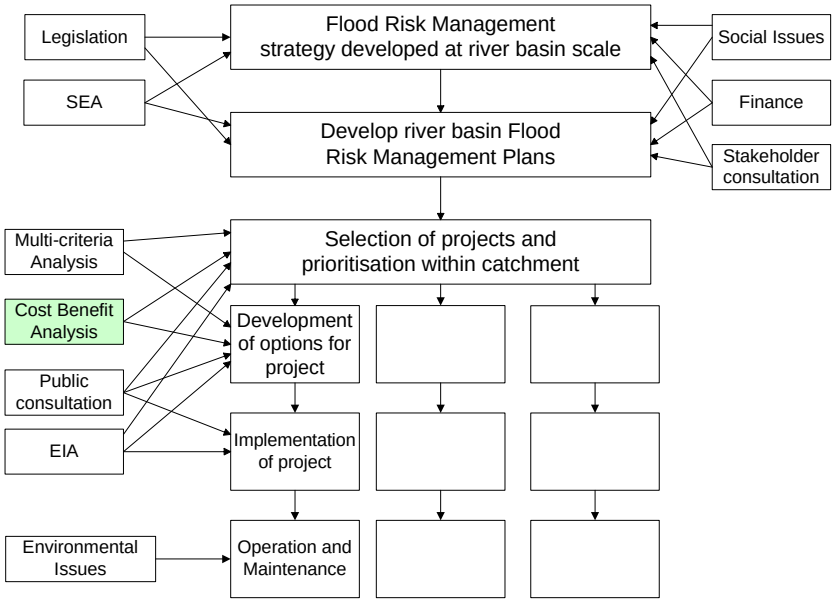
CBA is most credible when comparing projects of a broadly similar nature and aims, whose costs and benefits can largely be quantified and valued in monetary form. Cost-effectiveness analysis can also be used in the choice of alternative ways of meeting the same objective. CBA is of more debateable relevance for highly dissimilar projects, especially those with major non-quantifiable effects.

Many countries set *standards* for flood risk management projects, e.g. major infrastructure should offer protection against flood events of a specified severity (such as a return period[7] of 100 years). This can set up a potential conflict with criteria based on CBA, where the most attractive projects on CBA criteria do not satisfy national standards. This argues either for the use of the national standard as an overriding constraint, or for an iterative process exploring trade-offs (e.g. offering certain benefit areas a lower degree of protection)[8].

[7] frequency

[8] in the UK DEFRA can allow higher standards to be considered in this case – which implicitly means accepting a lower benefit-cost ratio for the preferred project.

5.2 COST-BENEFIT ANALYSIS (CBA)



CBA is a standard method of project appraisal, comparing the costs and benefits of a project. Values are monetised so far as possible, and the stream of net benefits is discounted to obtain a *net present value.* [9] The cost of a project is the loss to the rest of society from using the resources for this purpose rather than for something else.

If a project causes a *loss of benefits*, this too is a cost (e.g building a reservoir which destroys farmland). Costs can be either *tangible* (e.g. wages) or *intangible* (e.g. loss of amenity, destruction of wildlife habitat).

The main benefit of flood risk management is the avoidance or reduction of future damage or disruption from future floods. Quantifying this benefit requires a good knowledge and analysis of past floods, some system for modelling likely future floods, and a data base of populations, properties and habitats at risk. The main stages involved in benefit appraisal are as follows: [10]

- Define the maximum extent of future flooding and decide on the *benefit area*[11] for the assessment
- Assemble hydrologic/hydrographic and hydraulic data defining the flood problem
- Collect data on the land use and other characteristics of the benefit area
- Assemble depth/damage data for properties in the benefit area
- Calculate annual average flood damages to be avoided by the selected scheme options and the present value of these damages
- Compare costs and benefits and select prospective scheme

Though the broad approach of carrying out a CBA is clear, different methods can be used to assess both the costs and the benefits. European countries vary in their practice of flood risk management benefit assessment. Different methods have particular strengths and weaknesses and are appropriate for different circumstances.

[9] We assume readers are familiar with the rudiments of CBA. There are many textbooks and manuals on CBA. The UK's DEFRA also has guidance

[10] as presented in the *Multicoloured Handbook*, by Penning-Rowsell, et. al.

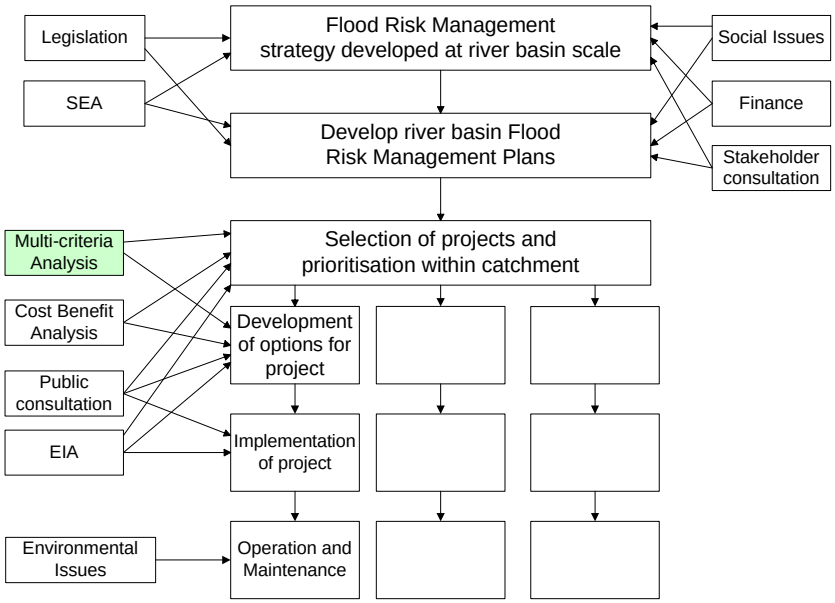
[11] the area affected by the flood problem, directly and indirectly.

Once the costs and benefits have been determined and reduced to a common price and time basis it is possible to compare the two. In economic terms schemes with a larger benefit/cost ratio are preferred over those with smaller benefit/cost ratios.

General guidance on a methodology for carrying out Cost-Benefit analysis is contained in the document produced by EC Directorate General Regional Policy (EC, 2006)

Annex 3 contains a more detailed discussion of Cost-Benefit Analysis.

5.3 MULTI-CRITERIA ANALYSIS & OTHER DECISION METHODS



CBA is probably the most common appraisal method for flood risk management. It is rigorous and capable of producing unambiguous results to guide decision makers. On the other hand, by reducing complex considerations to a single criterion, by its stress on quantification, and by leaving out of account factors that cannot be quantified, it may be considered to be too one-dimensional.

Other decision methods can be used which make more use of subjective or expert judgement, or which take account of attitudes to risk, especially of catastrophic risks such as of major flooding.

Multi-criteria analysis (MCA) is increasingly being used in the assessment of FRM projects, in preference to the sole reliance on single-criterion methods such as CBA. MCA permits the involvement of a wide range of stakeholders, and offers greater transparency to the decision-making process. It is also less "technocratic" than CBA, and is arguably more suitable where the effects of a scheme are non-quantifiable or intangible. In the experience of many practitioners, the main advantage of MCA is in the *process* rather than the *product*: the act of bringing different stakeholders together to focus on a common problem is more fruitful than any formal, numerical results that may be produced

The simplest form of MCA is to break down the appraisal into different subject areas (hydrological, economic, social, environment, financial etc) and to present the results of each analysis separately to the decision-maker (or committee) to take a subjective, or democratic, judgement. Although this procedure is highly judgemental, it avoids specialist analysts becoming involved in political, social, moral or other issues on which they have no standing.

A further step can be taken towards more rigorous MCA by applying numerical weights to the performance of each option against selected criteria. Assume, for example, that the main criteria for assessing a flood management project are effectiveness (in preventing flood damage), cost, economic (CBA), social (people affected) and environmental impact. If the choice were whittled down to three options (A, B and C), they could be scored against each criterion as follows (where 1=poor, 10=good):

Criterion	**Option A**	**Option B**	**Option C**
Effectiveness	5	10	3
Cost	6	1	7
Economic (CBA)	3	2	6
Social impact	7	9	4
Environmental	1	2	8
Total score	22	24	28

In this simple example, all criteria are given equal weight, and the preferred option is that (C) with the highest total score. One criterion could be given a higher weight than others: in this example, if "effectiveness" were given double the weight of the others, this would lead option B to be preferred. The attribution of weights between the different criteria is always likely to be controversial[12], but has the merit of being open and transparent.

Where an option is superior to others on all criteria, it is said to "dominate" them, whereas if it is better on some and worse on others a "trade-off" is required. In the above example, option B is highly effective, but very costly, whereas option C is the reverse.

There are many more sophisticated variants of MCA, described in Snell (1997), as well as a journal dedicated to this topic, *Journal of multi-criteria decision analysis.* Annex 3 contains more information on MCA.

5.4 SHORT-CUT APPRAISAL AND RANKING

Individual schemes selected for financing and implementation under a FRM programme should ideally be part of an overall strategy, and should satisfy the normal selection criteria following detailed appraisal. Some countries have rigorous procedures for selecting and screening projects, whereas others rely on simpler methods using less information.

This section proposes a method of *short cut appraisal* appropriate for situations where there is an urgent need to implement FRM projects but neither the data nor adequate skilled personnel to carry out the necessary detailed appraisal of each case. *Short cut appraisal is better than nothing, but not in any way an adequate substitute for full detailed appraisal: it should be regarded as a short term expedient pending the development of fuller and more satisfactory data and procedures. The form of SCA proposed here does not answer the question "is this project worth doing?", but it will assist in filtering and ranking projects for further study from a list of preliminary proposals on which data is limited.*

It is important to subject all proposals to some elementary scrutiny, even where data is lacking. This is just as true of proposals to replace existing damaged projects as for completely new schemes, since the original rationale for the project may have changed, and there may be better options available now.

The checklist in Box 7 offers a simple approach to screening proposals.

[12] Note that the absence of weights is also a judgement – namely that all criteria are of equal standing.

Box 7 Short-cut appraisal: a proposed check-list for project applicants

Purpose of the scheme (in 25 words)

Location

Strategic & policy context

- Is the project part of a coherent national Flood Risk Management strategy?
- Project category (e.g. reduction of flooding -structural/non-structural, new or replacement of existing structure, etc; reduction of susceptibility/mitigation of impact, etc.

Design standard

- (for structures) design standard (flood return period)

Features of benefit area:

- Characteristics of area that will be protected
  - Physical Area
  - Economic activities (type, value of assets, annual value-added)
  - Resident population
  - No. of houses
  - Key infrastructure

Environmental/sustainability aspects

- Has an EIA been undertaken already? Is an Environmental Statement required under legislation, as the project gone through any screening process with the relevant authorities? If it is not formally, is some form of assessment and reporting required to meet good practice requirements?
- What alternatives been assessed and why is this project preferred?
- Does it conform to or conflict with national & EU environmental legislation & Directives?
- Does it contribute to meeting WFD objectives?
- Are there any European or international level protected areas which could be affected and /or require appropriate assessment and provision of compensation habitat?
- Are there transboundary issues?
- Does the project have particular environmental sensitivity? (costs, benefits?)
- Is there potential for environmental enhancements, such as habitat creation, urban or townscape improvements or plans for regeneration or major development.
- Will the option require significant operational/maintenance inputs, eg energy for pumping or maintenance of flood defence walls?
- Has the sourcing of materials been considered?
- Has the carbon footprint of the option been considered, and have interest groups and potentially affected communities been consulted?
- What consultation has taken place

Damage from recent floods

- date of recent serious floods & return periods
- estimate of damage caused (categorised by type)

Costs

- totals
- disaggregation by main cost components

Key summary indicators

- cost per person at risk;
- cost per unit of economic value-added in benefit area; or, cost per unit value of economic assets
- cost per unit value of infrastructure at risk
- cost per residential property at risk

5.5 ENVIRONMENTAL ASSESSMENT AND SUSTAINABILITY

In selecting between options for a project one of the factors to be considered is the environmental impact. This implies that the options should be subject to some form of environmental assessment. The level and detail of this assessment will depend upon the nature of the project and its environmental sensitivity but some level of environmental assessment will be needed to inform the project options appraisal process and preliminary design.

Some types of options might also need to be subject to an EIA, as discussed above, under national legislation and a formal Environmental Statement (ES) will need to be published. It will be useful to identify which of the options fall within this category or will need a screening decision from the relevant authority as to whether an ES will be required. It will also be important to identify if any of the options potentially affect Natura 2000 sites (or proposed sites) and consider if habitat compensation may need to be provided. These issues can then be factored into the project planning.

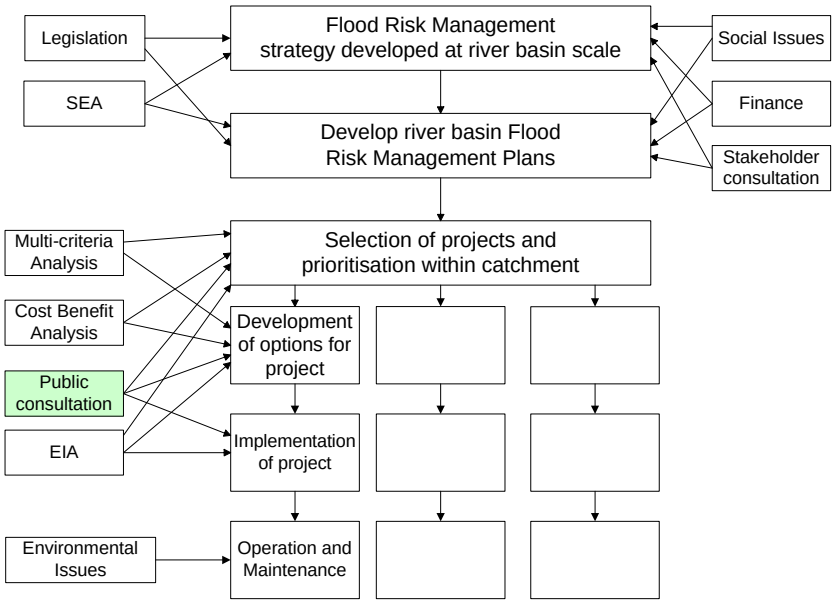
Typically options assessment would be informed by a desk based study looking at environmental constraints and opportunities and some preliminary site visits and surveys. Specific issues raised as a result of this options assessment might be discussed with key stakeholders.

A further consideration is the potential sustainability of the project. Many of the considerations outlined in Section 2.1 are factors in ensuring the sustainability of projects. Emphasis at this point is made to one or two specific issues. These are the selection of materials, the requirement for maintenance and whole life costs. Increasingly, the carbon foot print is being examined (this relates to the operational, construction energy consumption and the energy required for materials used) to consider the carbon/energy consumption over the life of a scheme and help identify better alternatives, improve design and operation. It is important to consider these at the project selection stage. The issue of maintenance and whole life costs is particularly important and these can have a major impact on the economics of different options.

As far as possible the environmental constraints and opportunities for the options should be considered along together with mitigation measures that might be possible and these discussed with engineers and designers to identify how options can be improved and see how this makes a difference to the decision on a preferred option.

If an ES is required (or an elective environmental report is to be provided) for the preferred option, the alternatives considered and reason for selecting the preferred option are usually provided in a scoping report for early consultation and will also be reported in the final ES or environmental report.

5.6 STAKEHOLDER AND PUBLIC CONSULTATION



As discussed in Section 4.7, public consultation and participation should be encouraged where appropriate. The issues during the development and selection of projects are similar to those discussed in Section 4.7 but, for detailed local schemes, the stakeholders and public involved in the process may be different. An important part of any public consultation project is to ensure that those participating are sufficiently well informed about the options and their implications to enable them to take informed decisions. Care needs to be taken that different options are presented in a balanced way.

As mentioned above, for some types of options a screening decision will need to be obtained from local authorities along with requirements for publishing the decision made. In some cases the authorities may define the scope of the EIA.

Whether or not an ES is a formal obligation or an environmental report is being produced to meet good practice, publication of a 'scoping report' can be a useful tool for early consultation with stakeholders and gives them an opportunity to comment on the options considered and the scope of the proposed EIA. These comments can also be fed back into the option design.

Where appropriate assessment is potentially required because impacts on a Natura 2000 site cannot be ruled out, additional consultation will be needed to agree with the competent authority the information that is required.

5.7 DEVELOPMENT OF OPTIONS AND DESIGN STANDARDS

The range of options considered should be as wide as possible and should include upstream or downstream works and soft engineering techniques, see Section 3.3.7 above.

Box 8 Selecting flood risk management options

There was serious fluvial flooding of homes and other properties on the south side of a major European city, with more than 20 significant floods in the last 100 years, arising from a river that flowed through the city. In 1984 more than 200 homes were inundated. A flood risk assessment identified that approximately 1,710 residential properties and 50 commercial properties were at risk of flooding in the 200 year event with some areas having a 50% risk of flooding in any one year.

A range of flood risk management options were considered including:
a) do nothing
b) provision of flood storage upstream
c) direct flood protection by the construction of walls and embankments
d) channel widening and improvement
e) channel re-grading.

Multi-criteria analysis (MCA) was used to select four options, with the MCA taking into account: Hydraulics, Economic/ Engineering, Environmental/ Planning and Social/ Political factors.

A public exhibition was then held explaining the scheme and the options and comments were invited from those attending. A workshop involving stakeholder organisations and the local authority then selected the preferred option, which consisted of:
a) the provision of three upstream storage areas
b) construction of low walls and embankments along the river
c) modifications to some bridges over the river.

Designs should be developed using appropriate national or international standards and Best practice guides. A wide range of guides are now available on the use of soft engineering techniques in river engineering. The use of such techniques may reduce the visual and environmental impact of schemes.

5.8 WATER QUALITY ISSUES

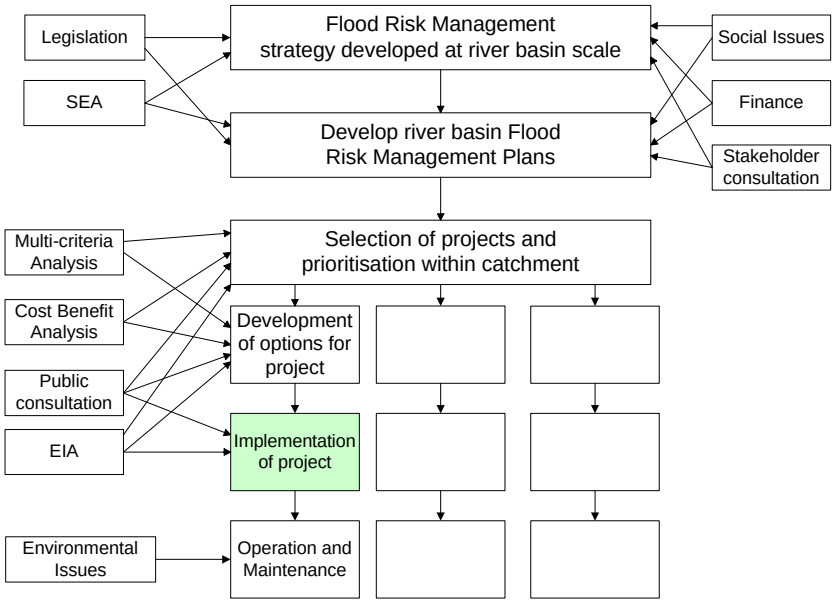
Flooding may result in the mobilisation and distribution of pollutants. This can occur in a range of different ways and over different spatial and temporal scales. The flooding of urban areas can lead to untreated or diluted sewage being released into rivers and water courses. During flooding, bank erosion and sediment movement may lead to the release and movement of pollutants bound to sediments. Such issues should be considered as part of Flood Risk Management and, where the potential impacts are unacceptable, then remedial works should be incorporated into Flood Risk Management Plans and projects.

Where there are significant potential public health concerns it may be advisable to implement water quality monitoring during flood events which can identify health risks to the public. This requires rapid sampling, analysis and dissemination of results.

Past industrial activity may lead to polluted sediment being present on the floodplains of rivers. Lateral river movement during floods may lead to the release of that sediment into the fluvial system. For pollution that is contained within the floodplain, changes in water level as a result of either floods or the construction of flood control structures may result in the release of pollution into the flow.

A checklist for issues to be considered in the selection of a Flood Risk Management option is given in Annex 6.

6. Implementation of projects



6.1 DETAILED DESIGN AND APPROVAL STAGE

Once a scheme has been selected then it is normally necessary to carry out detailed design. The design documentation should make clear the assumptions that have been made in the design process and the design conditions that have been assumed. Concerns about the impact of potential future climate change can be addressed by including allowances for future climate change in the design conditions.

Depending upon the complexity of the proposed scheme it may be necessary to carry out some form of modelling to predict the impact of the works, including any upstream and downstream impacts. The nature and detail of the modelling will depend upon the nature of the scheme.

It is important that environmental issues are addressed at the design stage. In designing works the impact of construction should also be considered. The design of the scheme should seek to minimise as far as possible the environmental impact of the scheme. Where damage to the environment is unavoidable, consideration should be given to whether there are opportunities for mitigation. Mitigation may be provided for the permanent works or for the temporary situation during construction. An iterative approach involving the design and environmental experts is useful to find the best solution to design and assessment.

Construction impacts and mitigation measures should be identified as part of the environmental impact assessment work and reported in the Environmental Statement (statutory) or EIA report (elective). They should be separately identified in the Environmental Management Plan which can be developed to be a key tool for environmental management during implementation stages..

Cost estimates developing the budget for the project should be careful to include costs of any mitigation or enhancement measures recommended as well as the general environmental management aspects of construction and operation. There are often environmental unknowns or risks that might only be possible to accurately design for or cost once work starts, for example archaeological finds or additional protected species that will need to be moved or avoided. Environmental issues should be considered as part of risk identification and included in contingency costing.

Box 9 Selection of environmentally friendly options

For example, if a drop structure is required to stabilise the bed of a river that might stop fish movement upstream then the use of structures that would allow fish movement such as a rock ramp should be considered. If this is not feasible then mitigation works should be considered, for example, the provision of a suitable fish pass.

During the design phase it is necessary to consider the maintenance that might be required in the future. The cost and potential environmental impact of maintenance should be considered.

Box 10 Importance of addressing maintenance issues

A flood risk management scheme through a town was designed on an active gravel bed river. The scheme involved deepening the channel to increase its flow capacity. Following construction it was found that during floods sediment deposited in the deepened section. To maintain the flood protection this sediment had to be removed every one or two years which was both expensive and environmentally damaging. Had the maintenance requirement been predicted then an alternative flood risk management option may well have been selected.

The final design should be subject to an approval process by the authority responsible for flood risk management to ensure that it is consistent with flood risk management policy and by the authority responsible for the environment to ensure that it meets environmental requirements.

6.2 EIA/EMP, PLANNING PERMISSIONS AND PERMITTING

Once a preferred option is selected, it will be important to identify whether it comes under the national EIA regulations, and if a screening decision is required (ie whether the option is likely to have significant environmental effects) and an Environmental Statement is to be published for consultation and submitted to the authorities. It will be important to include adequate time for each stage of the process in the project programme, including time for consultation on the ES.

The detailed requirements and procedures, in terms of which project may require planning permission and environmental impact assessment will vary from country to country. In some cases planning permission may be required but a formal ES may not be considered necessary, in others the proposed development may be a permitted development not requiring formal planning permission but might still need to be subject to EIA regulations.

In many cases, even if an ES is not formally required, some level of environmental information will often need to be provided to the authorities to obtain planning permission for example so that appropriate conditions can be set, for example restrictions on noise and working hours.

Other types of permit may be required as part of construction and implementation. Again these will vary from country to country but can range from specific issues such as licences to move protected species, permission for work to agreement on compensation habitat where a Natura 2000 site might be affected.

The ES or environmental report should include an Environmental Management Plan (EMP) which sets out how the issues raised through the assessment need to be addressed during subsequent stages eg further detailed planning, site preparation, construction, maintenance and operation.

An EMP (with associated maps) is an important tool not only to ensure that mitigation measures are identified and put into practice but that also to promote good environmental management on site and prevent issues arising. It can be used for example where any ground investigation is required to

identify specific constraints and ensure in particular that protected areas and archaeological interests are taken into account.

6.3 CONTRACT DOCUMENTATION - SOME KEY PRINCIPLES TO ENSURE EIA/EMP TAKEN FORWARD AND GOOD CONSTRUCTION PRACTICE APPLIED

Contract documentation should describe the works that need to be carried out and also any conditions on the way the works are to be performed, the materials used and their handling and any other issues in the performance of the works. It should attempt to anticipate problems that may arise and indicate how these will be resolved if they do. Clear contract documentation will increase the likelihood that the works will be constructed satisfactorily.

It is important that the issues raised during the design process and the EIA (as identified in the Environmental Statement or report) are passed to those responsible for carrying out the work and those responsible for supervising it. It is important, therefore, that such information should be included in the project documentation. The EIA report will include an EMP which should highlight potential environmental impacts or risks and propose works or action to protect the environment or to provide mitigation for environmental impacts. It is important that those responsible for any construction are made aware of these issues. Thus it is important that any documentation relating to construction contains the relevant information from the EIA/EMP. In addition to project specific issues identified through the assessment process, there are generic construction good practice measures which should be put in place to prevent for example, pollution from spills or damage from construction equipment.

Where possible, for example where some form of framework arrangement in place, contractors should be involved in the option design and EIA process and should be given the opportunity to comment on the EMP. They often have experience of practical solutions to the issues raised, they can sometimes highlight where proposals might be unworkable or be particularly expensive. They can also be useful in helping to cost mitigation and construction management measures.

Often, however, contractors will not be involved at the earlier planning and design stages, so it will be important that the contract documents require them to develop the EMP further so that they can implement it effectively. The contract documents should provide a mechanism for approval of the contractor's EMP and for design change management and approval, and for monitoring of EMP implementation. Review of draft contract documents by environmental experts can help to ensure that the contract adequately covers environmental issues.

Ideally all construction projects should include the implementation of an EMP and should distinguish between generic good environmental practice measures and specific actions which need to be taken to address issues identified through the EIA process.

Design changes which may occur during the construction period may need to be considered in terms of their environmental impact and responsibilities for dealing with this should be identified in the contract documentation and the respective roles of the different parties.

6.4 SUPERVISION OF CONSTRUCTION

In the construction of projects, systems and works, the application of engineering does not end with the delivery of project design drawings to the owner or developer. The production of a competent engineering design does not assure the owner or the public that the project will be safely constructed in accordance with the sound engineering principles and practice.

Engineering supervision of construction is required to ensure, among other things, correct interpretation and application of the design, and of the engineering principles which are expressed in it. In addition all engineering details cannot be totally addressed in the design phase—even in the most comprehensive drawings and specifications. Accordingly, it is necessary for engineering judgements to be made during the course of construction.

It is important to ensure that the supervision of the works includes ensuring that environmental issues are addressed as indicated by the EIA/EMP. This may include what works are carried out, how they are carried out and the timing of works. It is good practice to identify an 'Environmental Clerk of Works' or similar, with relevant environmental experience to monitor the contractor's implementation of the EMP. The level of involvement can be appropriate to the sensitivity and complexity of the works.

Inclusion of environmental management performance in any general key performance indicator monitoring for the contractor also helps to give weight to environmental issues.

Training of contractor staff to raise awareness of environmental issues is generally part of a standard environmental management approach but high level training needs might need to be considered for for example for contractors in a framework arrangement to improve understanding of environmental management where it has not previously been part of the construction culture.

6.5 NEED TO IDENTIFY ISSUES THAT MIGHT ARISE DURING IMPLEMENTATION AND TO ADDRESS THEM

The EIA/EMP may raise issues that need to be addressed during implementation of any scheme. As far as possible these should be identified and consulted upon during planning stages but occasionally for example a protected species might be identified during the works, or a design change may be assessed and issued raised. These may include:

a) the methods that can or cannot be used
b) additional detailed survey requirements and timing restrictions for effective surveys
c) access to the site, including recommended access routes or prohibited means of access
d) the nature of temporary works
e) the timing of the works

Box 11 Importance of timing of works

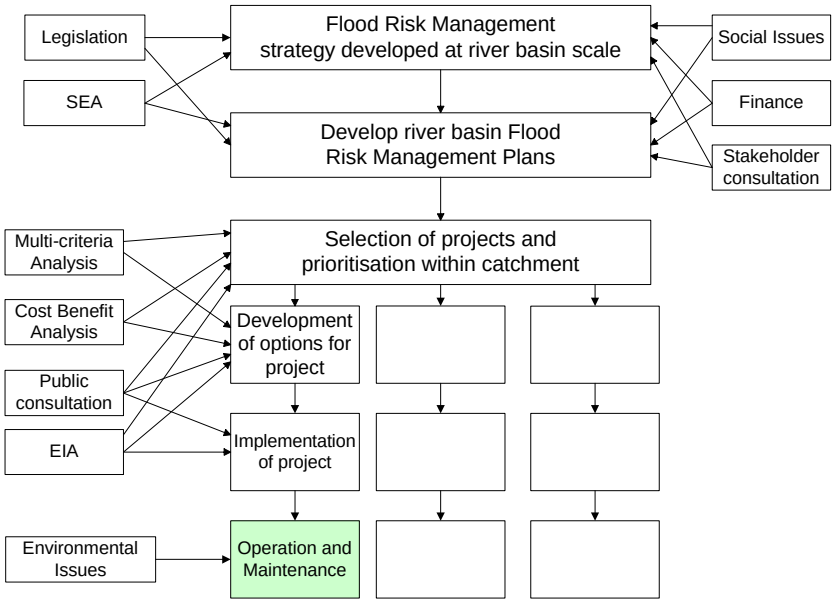
The survival rates for salmon eggs laid in gravel river beds is very sensitive to the concentrations of fine sediment in the flow. This is because the fine sediment may block the water pores in the gravel and, by preventing the flow of water, starve the eggs of oxygen. In salmon spawning rivers, therefore, it is common to prohibit works in the river channel that might lead to the release of fine sediment into the water flow during the spawning season. Commonly work is impractical during the flood season and so the period when certain types of in-channel river works can be carried out may be severely limited in salmonid rivers.

As noted above, it is vital that a procedure for dealing change is effective and that the implications of changes to proposals are assessed adequately. These can be design changes or arise from responses to changes in site conditions, or observations fed back from community or authorities so that environmental and other considerations such as risk to the public are assessed and acted upon accordingly and decisions recorded.

Community liaison can be an important task during construction/implementation. The level of involvement required will vary project to project but activities can include the following:

- Providing information to local communities making them aware of when works are starting and what they involve and who to contact if they have complaints
- Community meetings, monthly news letters, information boards
- Community projects especially for lengthy construction works to provide local benefits and maintain community relations and good will
- Dedicated community liaison officer who actively meets with local residents and groups to identify their concerns, keep them informed and feed back issues raised to the project team so that appropriate action can be taken.

7. Operation and maintenance



7.1 OPERATION AND MAINTENANCE PROCEDURES

All flood risk management projects will require some degree of maintenance. The nature and quantity of this maintenance should be identified during the project design stage. As part of the design process Operation and Maintenance procedures should be specified and appropriate guidance prepared. Wherever possible the impact of maintenance work on the environment should be minimised. If hydraulic modelling has been carried out with assumed hydraulic roughness values then guidance should be provided as to the maintenance required to ensure that this hydraulic roughness is maintained in the future.

7.2 ENVIRONMENTAL ASPECTS OF OPERATION AND MAINTENANCE

The operation or maintenance of a scheme can have major environmental impacts and these should be identified and addressed or mitigated during the selection and design stages of projects. These should be identified through the EIA/EMP if this was undertaken at the planning stages and this should have identified which issues are relevant to the operational and maintenance stages. In some cases an EMP may only have been produced for the construction stage. It may be necessary to produce a specific EMP to cover operation and maintenance activities or a least to up date earlier EMPs.

For example, the details of the operation of a flood retention reservoir can have major impacts on the ecology of the upstream and downstream reaches of river. Different operating strategies may have very different environmental impacts. The frequency and nature of channel maintenance can have a major impact on the ecology of rivers. In designing and selecting schemes it is important that these issues are identified and taken into account during project selection and design. For example, modifications to a river channel for flood risk management may encourage sedimentation in the channel in the future. The amount of sediment that will need to be removed and the frequency of such works should be identified as sediment removal can have a major impact on the riverine environment. This is an example of a type of operational issue that should be highlighted at the option appraisal stage so they can be taken into account in option selection. Preferred operating strategies should also be considered as part of the environmental assessment and option design so that once operational and maintenance stages are reached activities are essentially concerned with implementing activities

against clear objectives, targets and with appropriate monitoring/review so that operating strategies can be then refined accordingly.

Other aspects of maintenance that should be considered:

- Planting scheme maintenance and vegetation cutting or grazing
- Wastes generated from maintenance
- Materials and energy used in maintenance
- Manpower/staffing levels required
- Risks especially for mechanical equipment and for temporary structures.

7.3 RESPONSIBILITY FOR CARRYING OUT MAINTENANCE WORK

There should be clear arrangements for carrying out maintenance throughout the fluvial system, as required. This should be the responsibility of a designated authority. The aim of the maintenance in terms of acceptable flood risk should be specified and the system should be inspected periodically to ensure that this flood risk is being achieved.

As maintenance can have severe environmental impacts it is important that maintenance is only carried out when it is essential to maintain the required flood risk. Consideration needs to be given to the nature and frequency of maintenance to ensure that disturbance and damage to the environment is minimised consistent with providing the required level of flood risk.

8. Institutional framework

Flood Risk Management (FRM) comprises a variety of measures and it is rare that there is a single institution that is responsible for all such actions. Institutional arrangements for FRM are highly country-specific, in common with those for the water sector in general. The institutional arrangements frequently arise from a variety of influences which include; the nature of the flooding risk in the country, historical development of the institutions and political pressures.

As discussed above, within the EU there are a number of Directives that impact on FRK; the major two being the Floods Directive and the WFD. Any institutional arrangements should reflect the importance of their implementation and the need for an integrated response to these Directives.

If a number of institutions are involved then the best that can be hoped for is systematic coordination, routine consultation and joint decision-making on key issues between ministries and agencies, within a nationally agreed FRM strategy. This is particularly important and difficult when different disciplines are involved. Institutions should put in place arrangements to ensure that good practice and guidance is developed and disseminated throughout the institution. As part of this arrangements should be put in place to ensure that institutions learn from past experience and that staff receive the appropriate training and up-dating.

Finally, it is only realistic to acknowledge the political dimension to FRM. When floods happen, regional and local political figures may come under pressure to take decisions for the benefit of their electors (e.g. breaking dykes, releasing stored water) which may cause problems for others, and may be against the wider national interest. In drawing up a FRM strategy, similar national-local tensions may arise, e.g. over set-aside of farm land for polders or wetlands. The institutions involved in FRM must be both robust and flexible enough to cope with the underlying *realpolitik.*

9. Flood emergencies

9.1 INTRODUCTION

Flood emergency management involves:

- Preparing for flood events
- Flood response during the flood event and
- Post flood recovery

Though it is often advisable if Central Government takes the lead in ensuring emergency response at national, regional and local level, it is likely that it will be regional or local bodies who implement actions on the ground. One of the roles of Central Government should be to ensure that all those organisations involved in responding to flood emergencies are ready and able to carry out their part.

9.2 PREPARING FOR FLOOD EVENTS

Preparing for floods may involve a number of different actions, including:

- Raising flood awareness
- Providing flood forecasting and warning where appropriate
- Flood preparedness measures

It is important that people are aware of the flood risk in the areas where they live or work. The dissemination of flood risk information (including flood maps, where available) involves providing information to people in flood risk areas and explaining what the information means. Information that would be disseminated may include:

- The fact that some areas are at risk from flooding;
- The time of year when the flood could occur;
- The likely frequency of flooding;
- The likely depth of flooding;
- The rate of rise of the flood;
- The sequence of flooding including, for example, the areas that flood first;
- Whether the floodwater carries debris and/or mud;
- The duration of flooding.

Maps of flood risk areas provide vital reference information to all levels of flood management action. They highlight locations where flooding has or could occur, and are used to identify what is at risk. Comprehensive and accurate flood mapping is a major undertaking for any country. A combination of historic information, survey and hydrological evaluation is required. The water management authority should be assigned the duty of assembling and preparing flood mapping. Flood maps can be prepared using the following information:

- Measurements of flood levels and flows;
- Information on previous historical floods;
- Previous recorded and observed flood water levels;
- Topographic information on the area to be mapped.

Detailed flood maps should concentrate on the most densely populated areas. Areas that are less severely affected by floods, or which are sparsely inhabited, will require less detail in their flood maps.

Flood hazard is the impact of floodwater on people, vehicles and buildings. The production of flood hazard maps requires knowledge of the following:

- Flood extent;
- Flood depth;
- Flow velocity.

These should be obtained from local knowledge of previous flood events from local communities and the river basin authority, although they will only know about floods that have happened and not the possible larger floods that could occur in the future.

Floodplain modelling is an approach that can estimate the impact of possible larger floods, but is a high-cost technology requiring considerable effort to implement. A map of the areas at risk of flooding can be prepared by plotting all available information such as flood extents, flood depths and flow velocities from the river basin authority and local communities. Much of this information will be obtained from talking to people, so mapping should be an ongoing exercise, with information (for example, a flood depth at a particular location) being progressively added to the maps.

Box 12 Flood hazard classification using velocity and depth relationships

Figure 9,1 shows the relationship between flood depth, velocity and when it becomes unsafe to drive a vehicle or wade in floodwaters.

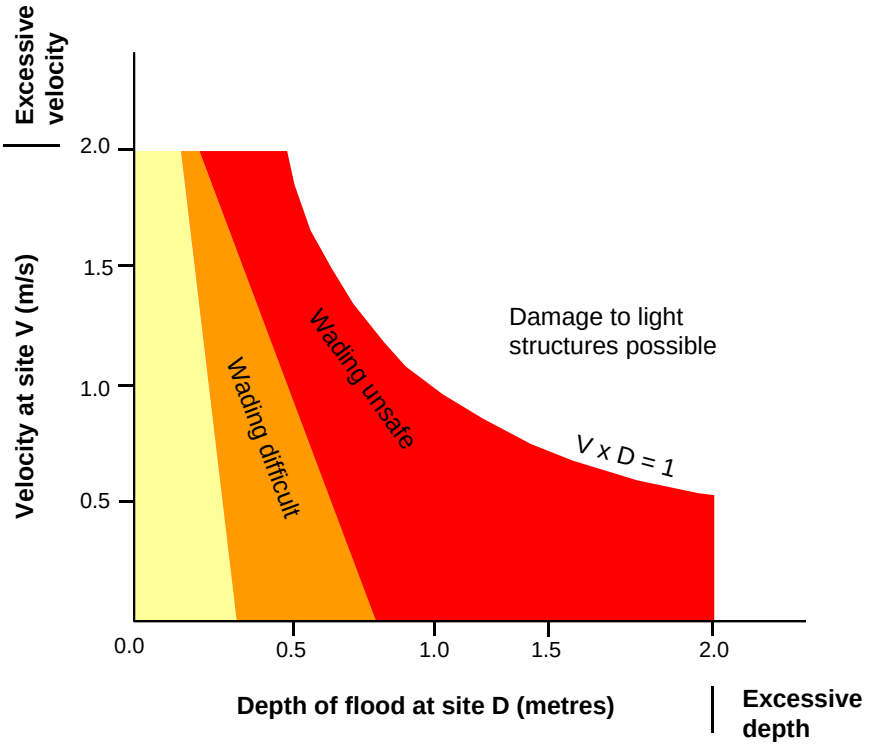


Figure 9.1 Unsafe wading depths and velocity

- At velocities in excess of 2 m/s the stability of foundations and poles can be affected by scour. Grass surfaces and earth begin to scour and become rough and unstable;
- The velocity of floodwater passing between buildings can produce a hazard that may not be apparent if only the average velocity is considered;
- Vehicle instability is caused initially by buoyancy;
- At floodwater depths in excess of two metres and even at low velocities there can be damage to light frame buildings from flotation, water pressure and debris impact.

Box 13 Hazard classification

Figure 9.2 shows a simple method of classifying the hazard in a floodplain based on the depth of the flood water and its velocity.

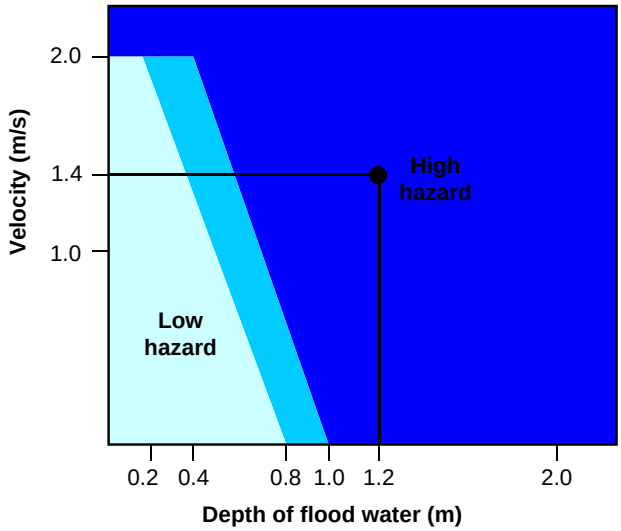


Figure 9.2 Simple method of hazard classification

The impact of the hazard on people may either be:

- Reduced by the establishment of an effective evacuation procedure;
- Increased if evacuation difficulties exist.

In the transition zone between low and high hazard the degree of hazard is dependent on the site conditions and the nature of the development. For example if the depth of water is 1.2 m and the velocity is 1.4 m/s, the hazard is high.

Box 14 Example of the effectiveness of flood hazard mapping in Japan

In March 2003, the Ministry of Land, Infrastructure and Transport in Japan developed a "Flood Hazard Map Manual for technology transfer". Utilising the manual, the Asian Disaster Reduction Centre (ADRC), with the co-operation with Fuji Tokoha University, developed an exercise for "Community Based Flood Hazard Mapping". The exercise is a simple and cost effective tool used to raise public awareness while fostering the active participation of the community. The tool was developed bearing in mind that in order to raise public awareness and to ensure smooth evacuation when a flood or another disaster is imminent, maps must be user-friendly and easily understandable for the community.

In the case of a flood, hazard maps need to include not only inundation areas and depth but also information such as evacuation centres and routes, disaster management centres, dangerous spots, communication channels and systems, evacuation criteria, tips for evacuation including emergency kits and other items needed in evacuation, and mechanisms and symptoms of hazards.

According to a survey recently conducted in Japan, among the residents who evacuated, those who had seen such hazard maps were 1.5 times greater in number, and they evacuated one hour earlier than their counterparts who had not seen a map. The results are shown in Figure 9.3. In case of an acute disaster such as a flash flood, this time difference could be a critical determinant in evacuation. The community

must be provided with relevant information regarding hazard maps and how to utilise them. Most importantly, how effectively hazard maps are used depends on the level of community awareness. The members of the community must be taught how to understand potential disasters in their area from the map to be able to take appropriate countermeasures.

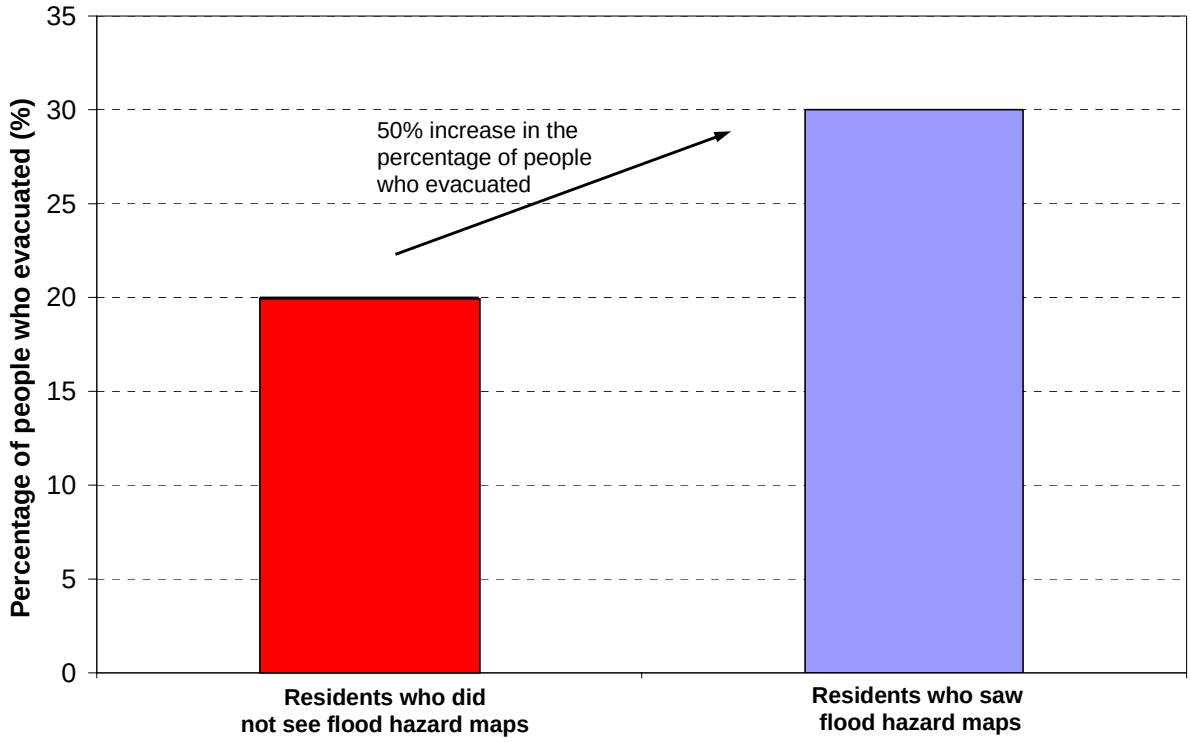


Figure 9.3 Effectiveness of flood hazard mapping in Japan

9.3 DISSEMINATION OF FLOOD MITIGATION INFORMATION TO REGIONAL ORGANISATIONS

The purpose of this activity is to disseminate advice on flood mitigation to regional and local authorities and Non-Governmental Organisations (NGOs) so that they can pass information on to communities who are at risk from flooding. It is important that flood risk and its management is as widely understood as possible. Experience has shown that NGOs or specialists in presentation media are more effective than government departments in conveying these messages to a public audience. These specialists should:

- Examine existing flood mitigation practices;
- Be supplied with good information and data, whenever possible government departments should adopt an open policy on data availability;
- Prepare public information material in accessible forms, for example school displays, flood awareness “road show”;
- Hold public awareness events at frequent intervals, preferably annually;
- Provide specific guidance and training on how to interpret flood maps and flood warnings;
- Test public awareness through surveys and questionnaires as to effectiveness of flood warnings, public understanding of warning and preparedness advice.

Considerable effort is required to present visually based information, and provide public presentations. Training of presenters in the technicalities of flood management is also required, through a team effort between respective professionals.

9.4 FLOOD PREPAREDNESS MEASURES

It is necessary to ensure that flood protection infrastructure is well maintained. If possible buildings in flood risk areas should be made flood resilient, that is, actions should be taken to attempt to reduce the potential damage resulting from flooding. If appropriate, evacuation routes should be identified and the information disseminated to the local communities. It may be advisable to take actions to protect essential services. This may involve moving key parts of a service to a location outside a flood risk area or undertaking works to protect the infrastructure from flooding.

The responsible authority should prepare Flood Emergency Plans which clearly state the actions that are required during a flood emergency and the authorities that are responsible for carrying out those actions. Actions may need to be taken by a wide range of bodies such as, police, fire service and local authorities. It is essential that these actions are coordinated and so emergency procedures should indicate how this coordination will be achieved.

It is advisable to periodically have exercises in which such Flood Emergency Plans are tested.

9.5 FLOOD RESPONSE

During a major flood it may be necessary to carry out emergency works to protect life or property. Emergency planning should clarify which bodies are authorised to carry out what type of emergency work. There is a risk that inexperienced or unqualified people may carry out work that increases flood risk rather than mitigating it.

It is recommended that emergency powers should lapse a short period after the recession of the flood; a period to be measured in days rather than weeks. If, for example, sediment brought down by a flood blocks a river channel then in a few days following the flood it would seem reasonable to use emergency powers to remove the sediment to significantly reduce the flood risk resulting from the deposited sediment. There would seem to be no reason why the replacement or reconstruction of damaged flood embankments months after the event should not be subject to the usual review and permitting procedures. It is suggested that emergency powers should only be used if subjecting the proposed works to the usual procedures would significantly increase the flood risk to the local population.

Even when using emergency powers the potential impact of works on flood risk and the environment should be considered. Consideration should also be given to possible long-term works that might be carried out following the event. It is good practice to try to ensure that short-term emergency works carried out either during or immediately following a flood event do not constrain possible future long-term schemes.

9.6 POST FLOOD RECOVERY

Emergency planning should also address post-flood recovery strategies to ensure that recovery from the flood is as quick and effective as possible. It may be necessary to have strategies in place for the restoration of essential services and the repair or replacement of damaged buildings. Floods can cause widespread disruption to economic activities and planning should address how this can be minimised.

Annexes

Annex 1 Short list of key references and sources of further guidance

References to other relevant Guides or Best practice documents

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Annex 2 FLOODsite project

FLOOD*site* is an Integrated Project supported by the EC Sixth Framework Programme within the Action on *Natural Disasters* in the Priority Thematic Area *Sustainable Development, GlobalChange and Eco-systems* and comes under DG Research. It is scheduled for completion in 2009.

The project is organised into 7 themes:

Theme 1: **Risk Analysis: Scientific knowledge and understanding**

Objectives
1.1 To Improve understanding of the primary drivers of flood risk (waves, surges, river flow etc.) through research targeted at key issues and processes that contribute most to current uncertainty in flood risk management decisions.
1.2 To Improve understanding, models and techniques for the analysis of the performance of the whole flood defence system and its diverse components, including natural and man-made defences (e.g. seawalls, embankments, dunes) and the extent of inundation.
1.3 To understand the vulnerability and sensitivity of the receptors of risk and to improve and harmonise the methods to evaluate societal consequences and to estimate flood event damages

Theme 2: **Innovative mitigation and sustainable flood risk management**

Objectives
2.1 To evaluate flood risk management measures and instruments ex-post (afterwards) and to develop sustainable flood risk management strategies and evaluate these ex-ante (before implementation) for a range of different physical and societal conditions.
2.2 To improve flood risk management measures that are applied during a flood event, through improved technology for flood warning in small flash-flood catchments and through evacuation planning

Theme 3 **Frameworks for technological integration**

Objectives
3.1 To integrate the scientific, technological and procedural advances to support long term flood risk management decisions.
3.2 To integrate the scientific, technological and procedural advances to support flood event management decisions.
3.3 To develop a framework for the identification and quantification of the influence of uncertainty in the process of flood risk management.

Theme 4: **Pilot Application sites**

Objectives
4.1 To provide real sites with real and specific problems upon which tools, techniques and decision support systems may be developed and tested.
4.2 To provide feedback into the research and development process from flood risk managers and river, estuary and coastal stakeholders.
4.3 To ensure that **FLOOD*site*** deliverables are of real value, practicable and usable.

Theme 5: **Training, Dissemination and Raising Public Awareness**

Objectives
5.1 To provide a series of Best Practice Guidance based upon the research outcomes

5.2 To disseminate, and support transfer, of knowledge to the stakeholder communities
5.3 To provide public educational tools (web-based) for school age children

Theme 6: **Project Networking, Harmonisation and Assessment**

Objectives
6.1 Link with external research and policy development activities
6.2 Provide internal coherence within the **FLOOD*site*** consortium (e.g. through the development of a common language of risk for flood management)
6.3 Integrate review and assessment into the project activities

Theme 7: **Project co-ordination**

Annex 3 Cost Benefit Analysis

Cost-benefit analysis (CBA)

1. Introduction

CBA is a standard method of project appraisal based on a comparison of the costs and benefits of a project. There are numerous texts explaining the general principles of Cost-benefit analysis, see, for example, EC (2006).

The cost of a project is the loss to the rest of society from using the resources for this purpose rather than for something else. If a project causes a *loss of benefits*, this too is a cost (e.g building a reservoir which destroys farmland). Costs can be either *tangible* (e.g. wages) or *intangible* (e.g. loss of amenity, destruction of wildlife habitat).

The main benefit of flood risk management is the avoidance or reduction of future damage or disruption from future floods. Measures which have this as their main aim may also have secondary impacts (e.g. ecological benefits, recreational opportunities) which should be reckoned in.. Quantifying benefits requires a good knowledge and analysis of past floods, some system for modelling likely future floods, and a data base of populations, properties and habitats at risk.

Though the broad approach of carrying out a CBA is clear different methods can be used to assess both the costs and the benefits. European countries vary in their practice of flood risk management benefit assessment. Different methods have particular strengths and weaknesses and are appropriate for different circumstances.

2. Estimate of costs

The cost of a project is the loss to the rest of society from using the resources for this purpose rather than for something else. The opportunity cost of land is its value in its best alternative use. In a freely functioning and undistorted market this is reflected in its market price. However, land is often treated as though it were free to the project and useless for anything else, whereas in reality it always has an alternative use.

Costs already incurred at the point of decision (e.g. a partially built project) should be disregarded for the purpose of the decision. *Sunk costs* should be ignored, and only *incremental costs* reckoned in. If a project causes a *loss of benefits*, this too is a cost (e.g building a reservoir which destroys farmland).

Costs can be either *tangible* (e.g. wages) or *intangible* (e.g. loss of amenity, destruction of wildlife habitat). Techniques are available for estimating *non-market* values, whether costs or benefits (Box 15)

Box 15 Estimating non-market values

Willingness-to-pay. People affected by the project are asked, through carefully crafted interviews or questionnaires, how much a particular change is worth to them. For a change adversely affecting them, they are asked their willingness-to-accept compensation. This method is also known as contingent valuation.

Defensive expenditure & avertive behaviour. Values can be inferred by observing what people actually spend in order to shield themselves from the effects of a project (e.g. aircraft noise, contaminated

drinking water)

Hedonic pricing. Used particularly for valuing environmental effects. It infers the values people place on environmental quality by observing what they pay for goods incorporating environmental attributes, usually their houses.

Travel cost. Peoples' valuation of the natural world or local amenity is inferred from the amounts they spend (time, transport) on travelling to the site in question.

Replacement cost & shadow projects. Where a project threatens a valuable site or habitat a budget can be included in the CBA to replace or relocate it. This can be regarded either as a real cost to the project, or as a hypothetical device to balance against its claimed benefits. A shadow project is one that would fully offset the negative effects of the project under study.

Costs can be *internal* to the project, or *external* to it (*externalities)*. An externality is a project impact which does not directly affect the project sponsor, and which the private sponsor will not normally factor into the decision to proceed[13/]. Certain *financial costs* should be excluded from CBA, such as taxes, financial transfers and depreciation allowances.

Contingencies are of two main kinds. *Physical contingencies* should, be excluded from CBA because the Base Case should be the best possible estimate of the project's contents and costs. *Price contingencies* that are merely attempts to provide against general inflation should also be excluded. On the other hand, *contingent liabilities* are real costs that should be included..

3. Estimate of benefits

The main benefit of flood risk management is the avoidance or reduction of future damage or disruption from future floods. This requires a good knowledge and analysis of past floods, some system for modelling likely future floods, and a data base of populations, properties and habitats at risk. The main stages involved in benefit appraisal are as follows: [14]

- Define the maximum extent of future flooding and decide on the *benefit area* for the assessment. This determines the area and populations at risk. For the environmental assessment (see below) this is important for the definition of the *benefits jurisdiction* – the population holding economic values for the environmental effects concerned.
- Assemble hydrologic/hydrographic and hydraulic data defining the flood problem. Projections of future flooding based on historical data will need to take into account climate change. For instance a 1 in 100 year flood event might become a 1 in 80 year flood in future.
- Collect data on the land use and other characteristics of the benefit area. Assessing benefits relies on detailed information about properties, infrastructure and the socio-economic status of residents.
- Assemble depth/damage data for properties in the benefit area. Data sets are assembled relating damage costs from previous floods to flood depth, allowing standardised unit values to be produced for different kinds of properties. Some of these unit values can be downloaded from insurance company websites, though care should be taken about the inappropriate transfer of costs to non-comparable situations.
- Calculate annual average flood damages to be avoided by the selected scheme options and the present value of these damages. There is still some variety amongst EU countries in the detailed approach to this process (Box 16)[15]

[13/] Unless the government *internalises* the externality by imposing a tax, or requiring polluters to clean up their processes, etc.

[14] as presented in the *Multicoloured Handbook*, by Penning-Rowsell, et. al.

[15] In addition to the paper of Meyer and Messner referred to in Box…, the paper by Cihak, Satrapa and Fosumpaur listed in Annex 1 is also relevant.

Box 16 National flood damage evaluation methods: A Review of Applied Methods in England, the Netherlands, the Czech Republic and Germany

"The report shows that the four countries…which feature very different histories of flood protection policy and different institutional settings, use sophisticated methods of flood damage evaluation. These in principle follow the same idea, namely trying to put economic values to elements of flood risk in order to estimate the benefits of flood protection measures in terms of prevented flood damage. In detail, though, the methods exhibit many different approaches. The major differences in flood damage evaluation methods relate to the damage categories considered, the degree of detail, the scale of analysis, the application of basic evaluation principles (e.g. replacement cost versus depreciated cost), and the application or non-application of results in benefit-cost and risk analyses. This diversity of flood damage evaluation methods, even in riparian states which share a major river, indicates that there is still a lack in transboundary cooperation in flood policy decision making in the EU".
Report by Volker Meyer & Frank Messner. UFZ Discussion Papers. Departmentof Economics, UFZ Leipzig. November 2005.

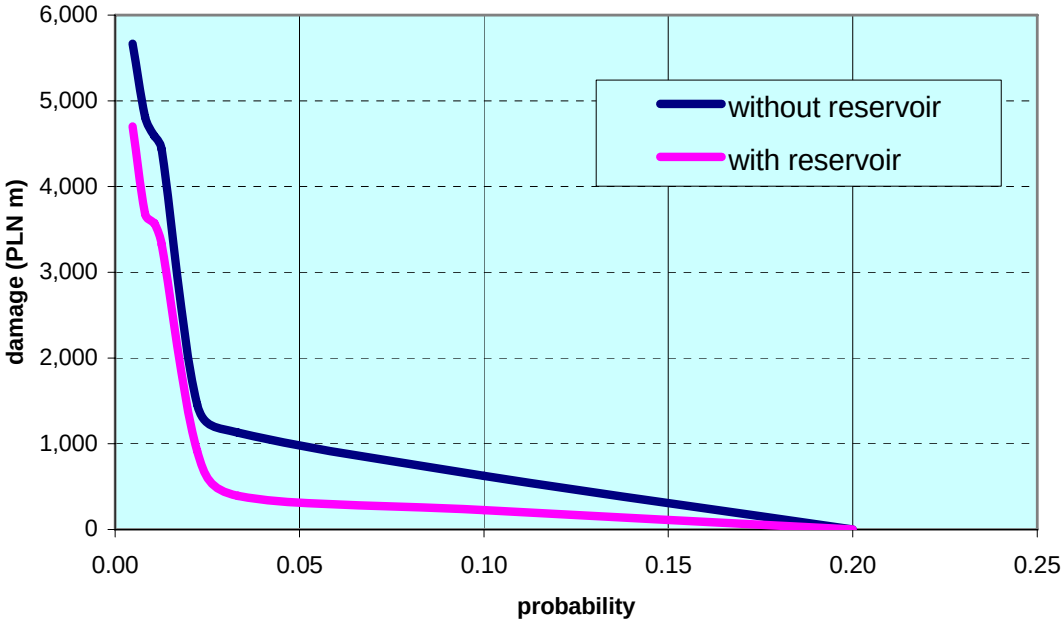
- Compare costs and benefits and select prospective scheme. Once the costs and benefits have been determined and reduced to a common price and time basis it is possible to compare the two. The main decision rules in CBA are the Net Present Value (of benefits net of costs) the Internal Rate of Return (the discount rate at which benefits and cost streams are equal) the Benefit/Cost Ratio and the Least Cost (of attaining a given objective). In some cases these criteria will give divergent rankings of schemes. Box 17 illustrates one such exercise.

Box 17 The Raciborz Flood Reservoir, Poland

The project is situated in the upper reaches of the Odra River in Poland and its purpose is to reduce the severity of flooding in the valley downstream. The reservoir will be formed by an earth embankment with a maximum height of 10.5m impounding a volume of 170Mm3 in an area either side of the river between the town of Raciborz and the border of the Czech Republic. The project involves the resettlement of 240 families from two villages.

The primary benefit of the project is expected to be the avoided costs of flood damage. There are also secondary benefits, consisting in this case of the exploitation of gravel from the bed of the reservoir. The reduction in flood damage is estimated as the difference between the flood damage that would occur without a reservoir and that which would occur with the reservoir. Unit rates for the damage suffered by various categories of land use were derived from examining date for the severe 1997 Odra flooding, and calibrated for a range of flood return periods from 5 to 1000 years.

The figure below plots estimates of flood damage against the probability of it happening (equivalent to the inverse of the return period). The benefit of the reservoir is indicated schematically in the figure as the gap between the two curves representing, respectively, the damages with and without the reservoir:



A notional estimate is also included for intangible damage – anxiety, loss of productivity, health problems, etc). Based on international experience 20% is added to the tangible flood damage to reflect these intangibles. For the main secondary benefit – sale of gravel from the site – the study considered the market for gravel in the immegiate vicinity and reckoned the real savings from the development of the reservoir on the cost of gravel extraction – c. 5% of its market value.

The internal rate of return of the project based on the primary benefits (avoided costs of flood damage) is estimated to be 12.8% for an economic life of the project of 30 years. If secondary benefits from the extraction of gravel are added, the IRR becomes 14.4%, which is in excess of the threshold opportunity cost of capital in Poland of 10%. Some sensitivity analysis was performed, showing that a 10% overrun on the cost of construction would reduce the baseline IRR to 11.3%.

Source: Feasibility Study for the Raciborz Flood Reservoir, Hydroprojeckt, Jacobs Gibb & Gibb Polska., 2004.

Distribution of costs and benefits between stakeholders

An application of CBA that is gaining favour in some countries consists of disaggregating the costs and benefits of projects from the viewpoint of particular economic interest groups.[16] This makes no difference to the overall merit of the project using aggregated decision criteria, but shows more clearly how it impacts on key stakeholders such as house owners, farmers, manufacturing industry, etc. The approach also identifies the impact of projects on different financial budgets, both public and private.

Breaking down CBA in this way gives greater clarity to the incidence of costs and benefits on different stakeholders, which is useful to understand the politics of different schemes. It can also allow the benefits of schemes to individual businesses or business categories to be estimated, providing a basis for the negotiation of third party financial contributions.

Sub sectors and benefit categories
Following the DEFRA/Middlesex approach, benefit assessment is disaggregated into the following principal sub-sectors and benefit categories:

[16] In the UK this is referred to as the "Sugden approach" after its main proponent. Further information from: www.risksol.co.uk , and www.defra.gov.uk/environ/fcd.

Flood damage to residential properties and related social impacts.
This category always has a very high social and political profile. It also has a high economic significance: direct residential property flood damage is disaggregated by house type (in the UK model 5 types), building ages (7) and socio-economic grouping of residents (4). Evidence is also becoming available of the intangible effects of flooding on health and psychic welfare. Other key variables in modelling damages are the depth of floodwater (*depth-damage data)*, warning period, and of course flood return period (frequency).

Flood damage to non-residential properties (NRPs).
NRPs are divided into "bulk" classes (retail, warehouse, office, factory) and non-bulk groups. Bulk properties are further sub-divided into several dozen more categories. The floor area in each detailed class is collated, and standardized unit values applied for each level of protection (e.g. 2-200 years). The resulting standardized values can be validated by site surveys for large valuable properties with a high flood frequency- though these visits are obviously time-consuming.

Road disruption & emergency costs.
This category includes indirect flood losses resulting from floods disrupting road communications and increasing costs of public agencies managing the flood incident and recovery phases. In all such cases, the relevant loss is the *economic* cost to society as a whole. The main cost of road disruption is the extra time and consumption of resources incurred by vehicles taking longer and travelling further to make the desired journey. These costs can be modelled using data built up from estimates of roads affected, traffic volumes, traffic costs, diversion routes, etc. The benefits of flood alleviation also include reduction in the costs incurred by various organizations in dealing with flooding and in the recovery process – these are likely to be highly specific to particular events and can perhaps best be estimated from historical records. The final item of cost is the actual damage to public infrastructure – e.g. to the fabric of roads, bridges, rail tracks, etc. where these are not included under other headings.

Recreational gains and losses.
This item covers benefits (or loss of benefits) from the enjoyment of landscape, wildlife and natural amenities, as well as direct enjoyment of recreational facilities. Benefit values can be modelled from data on visitor numbers to specific sites, duration of stay, distance travelled, willingness-to-pay evidence, etc.

Flood risk management for agriculture
The benefit of flood defence is regarded as avoidance of the likely reduction in the value of agricultural land. In practice, this is a difficult area of analysis. If flooding is frequent, or expected, this will already be reflected (*discounted)* in the value of the farmland. In some countries and regions flooding can even enhances soil fertility. The seasonal incidence of floods is a key factor – winter floods are usually less damaging than those later in the year when crops are at an advanced stage of growth. Pasture is little affected by temporary flooding. The type of crop and its sensitivity to inundation is another key variable.

Environmental benefits and costs
Flood risk management schemes have impacts on the natural environment, both positive and negative. Also, particular kinds of projects will have different environmental impacts compared to others, which should be a factor in their respective rankings. Up to a point, environmental impacts can be valued in monetary terms using well known and tried methods.[17] Where meaningful monetary valuation is impossible, the environmental impacts should be described and taken into account outside the CBA in a framework of multi-criteria analysis.

[17] See references in Annex 1, especially DEFRA, 2006, Eftec 2007, Snell 1997..

New guidance being prepared for use by the Environment Agency of England and Wales encourages the use of *benefit transfer* data for the valuation of environmental impacts[18]. Environmental effects of FRM schemes are considered in the framework of *ecosystem services*, namely, the goods and services generated by ecosystems or habitats. Such services are categorised as follows:

- *Provisioning services:* products obtained from ecosystems (food, water, wood, fibre, genetic resources, etc);
- *Regulating services:* benefits obtained from regulation of ecosystem processes (climatic, disease, water regulation & purification, pollination, etc);
- *Cultural services*: nonmaterial benefits (spiritual & religious, recreation & tourism, aesthetic, educational, etc);
- *Supporting services:* services necessary for the production of all other ecosystem services (soil formation, nutrient cycling, primary production).

All these services contribute to human wellbeing (welfare), though it is not always possible, or sensible, to isolate the impact of one – synergy is more common. FRM can lead to gains or losses in eco-services which can in many cases by valued in economic terms using the standard techniques of environmental economics. Economic value is derived from preferences about environmental quality, expressed in or inferred from willingness to pay or other market signals. Individual persons experience the environment through either its use or non-use values for them. *Use values* can be either direct (e.g. food, biomass, recreation) or indirect (ecological functions, flood control, storm protection). *Non-use values* arise from altruistic concern for others, the bequest motive for the welfare of future generations, and the existence value of the resource itself.

Estimating original economic values for specific environmental changes is not always feasible. There is growing acceptance of the use of *benefit transfers*, the use of data derived from one site or project to indicate the size of benefit (cost) in another comparable situation. This saves the effort, time and expense involved in conducting original research, and in many cases is the only feasible way of obtaining environmental values. Guidance and protocols are being developed for the use of benefit transfers, and several readily accessible data bases are available.[19]

Economic appraisal with limited availability of information
The data requirements of appraisal methods described above are potentially considerable, calling for resources, time and budgets that may be unrealistic in all circumstances. In these cases there is a place for appraisal methods and decision rules based on short-cut approaches, the use of standardised data sets, and the application of benefit transfer – to name just three possibilities.

Short-cut approaches effectively by-pass full appraisal if, as a result of preliminary investigation, it appears that magnitudes – of costs or benefits – are such that a decision can be taken without further refinement. Alternatively, the preliminary analysis may indicate what the critical variables would be, pointing to areas of investigation where attention should be focussed if resources were scarce or time constraints were pressing.

The use of *standardised data sets* and *computerised modelling* is also growing. Past floodings are analysed for data on areas at risk, and damage associated with different degrees of flood, and this data can be overlain with current evidence of settlement, the distribution of economic activity, etc derived from internet- based *geowebs.* The latter are becoming increasingly powerful and versatile, and some leading webs are freely accessible.

[18] eftec: *Flood and coastal erosion risk management: economic valuation of environmental effects*. Handbook for the Environment Agency for England and Wales. (Draft) August 2007.
[19] one of the largest is the Environmental Valuation Reference Inventory (EVRI) on www.evri.ca. Others are listed in the eftec Handbook, p. 27.

Benefit transfer is another method of economising on research and analytical resources, by selecting evidence from comparable situations elsewhere to give indications of the size and nature of impacts in the case in question. As noted above, this approach is gaining favour particularly for environmental economic estimation.

Annex 4 Multi-Criteria Analysis

Introduction

In arriving at a decision, one has to consider the scores achieved by each option on all the attributes. In carrying out a comparison of different options a distinction may be made between methods in which high scores for one attribute may be traded-off against low scores for another attribute and methods in which such a trade-off is not considered. These are often referred to as compensatory (trade-off) and non-compensatory (without trade-offs) methods.

For instance, in a rehabilitation scheme decision makers may be more concerned about the future visual appearance of the river than about bio-diversity. They might thus prefer an option in which visual appearance gets a high score and bio-diversity receives a low score to an option in which both achieve average scores. In this case the decision maker is prepared to trade-off benefits in the visual appearance against poor bio-diversity. There may be cases in which such trade-offs are not acceptable, e.g. where there are minimum acceptable levels of water quality - options scoring below this acceptable level may be rejected, however high their scores might be on aesthetics and social attributes.

The distinction between compensatory and non-compensatory methods is in part artificial. It may be possible to combine both methods. Thus one could consider setting minimum acceptable scores for all the attributes and reject any options that do not achieve these minimum scores. Options that do satisfy the minimum constraints could then be judged using a compensatory method.

a) Non-compensatory methods

Dominance

An option is 'dominated' if there is another option that excels it in one or more attributes and equals it in the remaining attributes. An option is 'non-dominated' if there is no option that excels it in all the attributes. Note that a non-dominated option may be excelled by other options on some but not all the attributes. It is possible, but highly unlikely, that one option will dominate all the other options. In this case this option would be the preferred one.

Though the concept of dominance is rarely useful in selecting a single best option it may be useful in eliminating some options. If one option is dominated by another then it can be eliminated from further consideration. Thus the concept of dominance can be used to reduce the overall number of options to be analysed.

One can determine the set of non-dominated options by carrying out pair-wise comparisons between the options and discarding any dominated options. All the non-dominated options, by definition, excel other options in one or more attributes. The decision maker may then select one of these options, possibly guided by the relative importance attached to the different attributes.

The practical difficulty in applying this method is that simple dominance on only a few or even only one attribute ignores all the remaining attributes. Thus the decision is only being made on a limited set of objectives. Unless there is a belief that these are the only objectives that are important it is unlikely that the selected option will be acceptable.

Satisficing methods

In this approach the decision maker first has to select minimum acceptable scores for each attribute. Any option is considered to be acceptable provided that the scores on all the attributes exceed the minimum acceptable ones. If the acceptable scores are set too high then no option will satisfy the

requirement, and *vice versa* where minimum acceptable scores are set too low. It is rare that this approach comes up with a single acceptable option. The main use of this approach is often to segregate the options between those that are acceptable and those that are unacceptable.

In a variant of this approach, the decision maker assigns minimum acceptable scores to all the attributes. For an option to be acceptable it need only exceed the minimum score on at least one attribute. Thus if an option exceeds the minimum acceptable score on one attribute then it will be considered to be acceptable independent of the scores on the remaining attributes.

Sequential elimination

In some situations a single attribute may dominate all others in the mind of the decision maker. An example of such an attribute might be cost. In some situations the issue of cost may over-ride all other considerations. In this situation one can compare all the options on this one attribute and if there is a single option with the highest score (when cost is being considered this would be equivalent to the lowest cost) then this would be selected. If there are two or more options with the same highest score then these options are then compared on the next most important attribute. The process can then be repeated.

The method thus requires the decision maker to rank the attributes in order of importance. It also assumes that within this order each attribute completely dominates those below them in the order.

Maximin

This approach selects that option which has the largest minimum score. In essence the method tries to select the best option in the event of a pessimistic scenario. The selection procedure is to determine the lowest attribute score for each option and then select the option with the highest value of those minimum scores. Thus each option is represented by the lowest scoring attribute and all other attributes are ignored. This may be an appropriate method if one wants to achieve the highest possible minimum standard, for example, if safety is involved. As the method concentrates on the lowest scored attributes and ignores the more highly rated attributes it may not be appropriate when considering river rehabilitation. As the method treats all the attributes similarly and the decision can be based on any of the attributes it is not an appropriate method where the decision maker considers some attributes to be much more important than others.

Maximax

This approach is based on a positive approach to the selection of options. The idea is to concentrate on the maximum scores and to select the option which has the largest maximum score.
In essence the method tries to pick the best of the best. The selection procedure is to determine the highest attribute score for each option and then select the option with the highest of these maximum scores. As the method treats all the attributes similarly and the decision can be based on any of the attributes it is not an appropriate method where the decision maker considers some attributes to be much more important than others.

b) Compensatory methods

It may be that one option scores very highly on one attribute but less well on other attributes. The decision maker may prefer an option that scored less highly on the first attribute but more highly on one or more of the other attributes. In these circumstances there is a trade-off between the low score of the first attribute and high scores for other attributes. A number of methods of analysis are based on this concept. The main issue for the decision maker is to determine the relative values of the different attributes; what increase in the scores of other attributes would the decision maker accept in return for a unit reduction in score for the first attribute.

Weighted sum method

In this approach weights are assigned to each attribute. The total score for an option is then defined as the sum of the scores for each attribute multiplied by its weighting This method assumes that the contribution of one attribute to the total score is independent of the scores for the other attributes.The determination of the appropriate weights depends upon the decision maker's preferences. Methods are available to help the decision maker to derive suitable values. The weights may also need to be subject to revision, depending on the results of the analysis.

Selection of an appropriate method

The above has demonstrated that a number of MCA methods are available, none of which is "correct" in all circumstances. Different methods can also be used in combination. For instance, if it were decided that there were minimum acceptable levels for water quality and environmental aspects, . The decision maker may not be prepared to accept a trade-off in which the scores for these attributes are reduced below these minimum acceptable levels. In this case the decision maker may apply a Satisficing method to eliminate all the options with scores below these minimum acceptable ones. When considering the remaining options, however, the decision maker may be prepared to accept trade-offs and a weighted sum method may be used to select the final option.

Annex 5 Checklist for issues to be considered during the development of a Flood Risk Management Strategy

EIB Flood Review

Check list for FRM

1) Legislation provides appropriate powers to those institutions responsible for FRM

2) Where the delivery of FRM is split between institutions, there are clear mechanisms for integrating activities and collaboration

3) Institutions responsible for FRM have in place arrangements to ensure that good practice and guidance is developed and disseminated throughout the institutions

4) Arrangements are in place to ensure that institutions learn from past experience

5) Institutions responsible for FRM have arrangements in place to ensure that staff receive appropriate training and their knowledge is up-dated as appropriate.

6) The general principles contained within the document 'Best Practice on flood prevention, protection and mitigation' are applied

7) Flood Hazard Maps have been prepared or are in the course of preparation for all flood zones and are available to public

8) Flood Risk Management Plans (FRMPs) are available or are in the course of preparation for all flood zones. FRMPs should take advantage of the use of non-structural measures and flood warning in addition to structural measures, as appropriate.

9) FRMPs have been subject to SEAs

10) The selection and prioritisation of Flood Risk Management Projects to implement FRMPs is carried out on the basis of clear, transparent procedures. These procedures may involve the use of CBA or MCA, as appropriate.

11) Flood Risk Management Projects are subject to EIAs, as appropriate

12) Procedures are in place to ensure that Flood Risk Management Projects are subject to public consultation, as appropriate

13) Planning controls are in place to encourage future development either takes place outside flood risk areas or is flood compatible

14) Procedures are in place for the design, approval, management and monitoring of individual schemes

15) Procedures are in place for the management and monitoring of the overall flood risk management programme at local and national level.

16) Procedures are in place to ensure that schemes are operated and maintained appropriately

17) Emergency plans are in place and appropriate exercises are carried out regularly

18) Emergency powers have limited duration following a major flood event.

19) Trans-boundary rivers. International agreements are in place relating to any trans-boundary rivers

20) FRMPs for trans-boundary rivers ensure that the ability for downstream countries to provide flood risk management is not compromised

21) FRMPs take into account any potential future climate change

22) The design of projects takes into account uncertainties in the design objectives and procedures

23) The risks associated with any plan or project are identified and controlled as appropriate.

Annex 6 Checklist for issues to be considered during development of a Flood Risk Management project

EIB Flood review

Checklist for developing options for Flood Risk Management projects

1) Have upstream storage or land use options been considered?

2) Has the use of soft engineering techniques been considered?

3) Will the proposed works have an adverse impact on the environment?
If so, can these be reduced or removed by modifying the scheme or can mitigation measures be carried out to reduce or remove the environmental impact?

4) Can environmental improvement be included in the scheme?

5) Has public/ stakeholder consultation been carried out?

6) Have potential upstream or downstream impacts been identified? If there are potentially adverse upstream or downstream impacts can these be removed or mitigated?

7) Has the impact of potential climate change been taken into account?

8) Have potential impacts during construction been considered? If there are potentially adverse impacts can these be removed or mitigated?

9) Have the risks associated with the project been identified?

10) Have the uncertainties in the design parameters of the project been allowed for in the design?

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