A Floods Working Group (CIS)

Resource document

Flood Risk Management, Economics and Decision Making Support

Title: A Working Group Floods(CIS) resource document "Flood Risk Management, Economics and Decision Making Support"

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Author(s): This document is based on the preparatory scoping paper (EU DG ENV project 10775, carried out by ARCADIS), and input from the WG-F Thematic workshop "Floods and economics: Appraising, prioritising and financing flood risk management measures and instruments" together with the results of the questionnaire submitted by EU Member States in relation to this workshop, under the supervision of the workshop planning committee. The Resource document has then been further developed by Belgium(mainly Filip Raymaekers, VMM), with contributions from an editorial group(France, Belgium and the European Commission, DG ENV.D.1).

The work programme of the CIS Working Group F for 2010 to 2012 includes the delivery D.1 "Report on flood risk management, economics and decision making support" The aim of the final deliverable of the Report is that it should serve as a resource document for the process of preparing flood risk management plans, in particular the consideration of costs and benefits and prioritisation of measures. **The mandate for Working group F is part of the Workprogramme for the Common Implementation Strategy 2010-2012**, available on Europa: http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

Information on the **Ghent WG F Thematic workshop on Floods & Economics** and other relevant documents can be found on the CIRCABC website.

Resource document on flood risk management, economics and decision making support

October 2012

Working Group F of the Common Implementation Strategy for the Water Framework Directive

Executive summary

The implementation of the European Floods Directive 2007/60/EC requires European Member States to draft maps and plans for the management of flood risks. The plans will consist of objectives for flood risk management and measures to meet these objectives. The measures will focus on prevention, protection and preparedness. Measures will have to be prioritised, taking into account relevant aspects like costs and benefits. Increase in flood risks due to possible impacts of climate change and expected changes in wealth and population, in a situation where authorities face limited financial resources, urge the need to focus on efficiency when selecting the best mix of measures to manage flood risks. Economic assessments within a long-term time perspective are a prerequisite to start this process.

Flood risk management must be part of an integrated and sustainable water management. Working on win-win measures and meeting multiple objectives can upgrade the efficiency of flood risk management measures considerably. The Floods Directive is closely connected to the Water Framework Directive 2000/60/EC. Both directives make explicit and implicit references to economic assessments. These links and references are explained in part 2 of the document.

The general decision framework as proposed in part 3 of this document reflects the linkage between the concept of risk, the assessment of flood risk and the evaluation of measures to reduce flood risks. It consists of a two-step approach. The first step is to calculate flood risk of a certain area under the baseline conditions. The second step is to recalculate the risk after realisation of risk management measures. It is proposed that these calculations take the possible effects of climate change and expected evolutions of population and wealth into account. Working within a general decision framework allows flood risk managers, stakeholders and politicians to evaluate different possible strategies and to compare the efficiency of different measures to reduce flood risks. The different building blocks of the general decision framework are explained in parts 4 and 5.

The applied concept of risk as being the combination of flood hazard and flood consequences, and the way in which it is calculated should ideally run through the implementation of the Floods Directive, starting from the preliminary flood risk assessment, over the mapping of hazards and risks, up to the setting of objectives, the selection of risk reduction measures and the implementation of flood risk management plans. In practice different methods will be used depending on the scale and level of detail of the assessments.

Floods have consequences on the economy, human health, the environment and cultural heritage. Economic assessment of flood risk is basically about calculating the averaged annual costs of damages or losses, and economic assessment of flood risk management measures is about balancing the reduction of these annual damage costs against the average annual costs of risk reduction measures over their lifetime, which is a cost-benefit analysis in its simplest form. But looking at the other types of impacts besides the economical one, risk assessment also has to deal with non-market assets and impacts, both negative and positive, for which expression in monetary terms is sometimes not possible or not desirable. Non-market impacts can be monetised in an indirect way in order to keep the concept of cost-benefit analysis as the overall method to underpin the selection and prioritisation of flood risk management measures. There is a growing consent however that traditional cost-benefit analysis should be supplemented by a multi-criteria analysis to evaluate both monetary and non-monetary impacts. Cost-efficiency analysis could be seen as an easier and more straightforward way of looking at efficiency of measures. The problem with this type of analysis is that it is a one-dimensional analysis, meaning that it is only applicable when the objective of flood risk management would incur reaching one single criterion, for example the protection against a certain

return period of flooding. Since flood risk management however is an instrument of sustainable development, the evaluation of different strategies and measures should be multi-dimensional.

Part 6 of the document looks at the availability of resources for financing flood risk management measures, and the role of insurance systems as a way to redistribute the financial consequences of flooding.

There is no one size fits all solution for risk assessment and evaluation of risk reduction measures. The choice of the method, the level of detail, the selection of assets at risk, the kinds of consequences taken into account, they all depend on local physical and political circumstances, availability of data and resources, and the evolution of experience, knowledge and research in the field of floods and economics. This document should serve as a living resource document for the process of preparing flood risk management plans, in particular the consideration of costs and benefits and prioritisation of measures.

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Glossary of terms used[1]

Awareness – It is essential that people recognise flooding as part of their environment. Communities must be aware of being at risk. To be aware of a risk means to have recognised it, to know about it, not to for-get or to repress it and to take it into ac-count appropriately when acting.

Consequences/impacts/effects – An impact points at the economic, social or environmental damage that may result from a flood. An impact may be expressed quantitatively or qualitatively. The terms consequence, impact and effect can be used interchangeably. Note that there can be beneficial and adverse consequences from flooding. Note also that the term impact is also used to denote (expected) changes that result from a particular action like e.g. a flood risk management measure.

Cost based approaches – The costs of e.g. replacing ecosystem services or certain values, avoiding damages due to lost services or providing substitute services all give an indication of the magnitude of the benefits provided by ecosystems, cultural heritage. These approaches, however, are not based on people's willingness to pay for a particular service and thus do not effectively reflect how society values a particular service. The method may be used as a sort of lower bound estimate. However, economists warn to use cost-based approaches with great caution if they should be used at all. It is not unlikely that costs of enhancing a certain service by artificial means surpasses the actual value of the service, thus potentially leading to overstating the benefits (Farber et al., 2002; NRC, 2004 and Millennium Ecosystem Assessment, 2005).

Direct effects – Direct effect cover all varieties of harm caused by the immediate physical contact of flood water to humans, property and the environment.

Emergency response – Developing emergency response plans in the case of a flood.

Flood - Flood is the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems.

Flood hazard – Flood hazard is the combination of the probability of flooding and the corresponding exposure characteristics like flood depth, velocity, duration, rise rate, period of occurrence and water quality. A hazard has the potential to lead to flood impacts if there are receptors present that are vulnerable to the hazard.

Flood hazard data – A flood hazard can be described in terms of flood depth, velocity, duration, rise rate, period of occurrence and water quality. Depending on the particular vulnerabilities of the receptors considered different flood characteristics become more important. Flood hazard data can be either modeled or based on observations.

Flood prevention – Preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices.

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[1] Largely based on Halcrow (2009), Water Directors (2003) and the European financed FLOODsite project. In the final document the source of the specific definition will be indicated as appropriate.

Once there is agreement on definition of terms as summed up in the 'Floods directive related terminology' document, this glossary of terms will be replaced by a reference to the approved terminology document.

Additional definitions can be found in the results of the Floodsite project http://www.floodsite.net/html/partner_area/project_docs/T09_06_01_Flood_damage_guidelines_D9_1_v2_2_p44.pdf - page 161; and http://www.floodsite.net/html/partner_area/project_docs/T32_04_01_FLOODsite_Language_of_Risk_D32_2_v5_2_P1.pdf

Flood protection – Taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location.

Flood risk – Flood risk is the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event.

Flood risk assessment method – A flood risk assessment method defines the formal process used to determine the impact to a specific receptor. The methods for the assessment of the consequences of flooding at least combine flood hazard and receptor location data, but very often also receptor vulnerability and value data. Depending on data availability, knowledge, available resources (money, time, personnel), desired level of detail, flood characteristics to be considered the methods for assessing the likely impacts of flooding to a specific receptor vary from very basic (only counting the receptors-at-risk) to quite advanced (counting the absolute impact to the receptors-at-risk in monetary terms or another value scale).

Hedonic pricing method – Hedonic pricing methods can be applied to estimate the value of a site or some of its characteristics by observing the prices of marketed goods. The method is based on the assumption that environmental characteristics are valued by people and that these are reflected in the prices of certain goods (USEPA, 2002). The most common application of this technique rests on the use of residential housing prices.

Indirect effects – Indirect effects are effects caused by the consequences of the physical contact of flood water with damageable property.

Intangible effects – Intangible effects cover impacts to those goods and services that are not traded in the market and, consequently, are far more difficult to assess in monetary terms than tangible effects.

Monte Carlo analysis – Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results.

Preparedness – Informing the population about flood risks and what to do in the event of a flood.

Production function methods – The production function method, also referred to as 'factor income method', assesses the value certain services (e.g. ecosystem services add to marketed goods. It is thus assumed that ecosystem services serve as an input to produce other goods that directly yield utility. Consequently, changes in the quantity and/or quality of ecosystem services may influence the provision, or at least the costs of providing other goods.

Receptors(-at-risk) – Receptor refers to the entity that may be impacted (a person, property, habitat, etc.). For example, in the event of heavy rainfall (the source) flood water may propagate across the flood plain (the pathway) and inundate housing (the receptor) that may suffer material damage (the impact or consequence).

Receptor value data – The value of a receptor is used to translated the degree to which a receptor is impacted into the corresponding loss or damage to society. In its most straightforward form the receptor value is expressed in monetary terms. An alternative could be a sort of (semi) quantitative or qualitative scale.

Receptor vulnerability data – There broadly exist two approaches on the basis of which the vulnerability of receptors can be characterised. The first type consists of the so-called depth-damage functions, which may be extended to incorporate other flood characteristics as well. The second type is an index based approach.

Recovery and lessons learned – returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.

Resilience – The resilience of a receptor-at-risk points at a receptors' capacity to recover from the adverse impacts from flooding.

Susceptibility – The susceptibility of a receptor-at-risk points at the degree to which a receptor may be adversely affected / damaged when it is flooded.

Tangible effects – Tangible effects include all kind of damages to those goods and services that are traded in the market and, consequently can easily be expressed in monetary terms.

Travel cost method – The travel cost method (TCM) is commonly used to estimate the value of recreational benefits. The technique is based on the assumption that the recreational benefits of a site are reflected in people's willingness to pay to get there. The utility of this method for the valuation of benefits other than recreation is limited. (USEPA, 2002 and Millennium Ecosystem Assessment, 2005).

Vulnerability – The vulnerability of the receptors-at-risk is a function of their susceptibility and resilience to flooding.

Abbreviations

CBA – Cost benefit analysis

CEA – Cost effectiveness analysis

CIS – Common Implementation Strategy

EA – Economic assessments

FRMP – Flood Risk Management Plan

INSPIRE – Infrastructure for Spatial Information in the European Community

MCA – Multi-criteria analysis

MS – Member State

PFRA – Preliminary Flood Risk Assessment

RBMP – River Basin Management Plan

TEEB – The Economics of Ecosystems and Biodiversity

WFD – Water Framework Directive

WG-F – CIS Working Group F on the implementation of the Floods Directive

1 Introduction

Floods constitute a significant risk to human health, economic activity, cultural heritage and the environment in Europe. Flood risk is expected to even increase. The reason for this is mainly twofold. Firstly, there is a marked increase in the number of people and economic value of the assets located in flood risk area. Secondly, human activities (through climate change, increase of the soils' impermeability or deforestation) are likely to increase the magnitude and frequency of floods. As a result it is believed flooding has the potential to undermine the EU's drive towards sustainable development.

Flood management has predominantly been about 'preventing flooding'. Floods, however, are part of nature and will continue to exist. Flood protection is never absolute. It is neither technically feasible nor economically affordable to prevent all properties from flooding. Therefore, a risk-based approach is taken to achieve the best results possible using the budget and resources available. Flood management should seek to limit flood risk, but not at all costs. The costs should be reasonable compared to the expected benefits.

The way flood problems are tackled often starts from a wrong perspective; focussing too much on local protection, neglecting the broader picture. The way forward is to adopt a coordinated, long-term and integrated basin level approach. In order to manage the flood problem in an optimal way flood risks of all kind have to be assessed and mapped; covering impacts to economic, social, cultural and ecological receptors. This report aims at identifying and drafting practices and methods for assessing flood risks and the benefits of flood risk management measures, such as damage avoided, as well as other aspects of economic assessments, to support decision making in the framework of flood risk management.

In anticipation to all of the above the Directive 2007/60/EC on the assessment and management of flood risks, hereafter referred to as the Floods Directive, sets out a framework for an efficient and effective flood risk management. The Floods Directive aims at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity.

The Floods Directive has important links with Directive 2000/60/EC which establishes a framework for Community action in the field of water policy, better known as the Water Framework Directive. Measures implemented in the framework of the Water Framework Directive may also promote flood risk reduction by e.g. the restoration of wetlands and flood plains. Because of the synergy between both Directives some Member States have already considered flood risk management related aspects in their first River Basin Management Plans. The Water Framework Directive requires the development and selection of cost-effective programmes of measures. Similar economic considerations are also important in the framework of the Floods Directive. The thinking and work on economics that has been done with regard to the implementation of the Water Framework Directive shall therefore also be considered in this context. Care shall be taken to ensure that the efforts on flood related economics rather promote synergies than overlap with the work carried out for the Water Framework Directive.

The successful and effective implementation of the Floods Directive raises a number of shared technical challenges for the Member States, the Commission, the Candidate and EEA Countries as well as stakeholders. The shared challenges with the implementation of the Floods Directive are addressed by Working group F on Floods of the Common Implementation Strategy (CIS) for the Water Framework Directive. An important issue with regard to the Floods Directive concerns the requirement to *"take into account relevant aspects such as cost and benefits"* when developing flood management plans.

The role of economics in the implementation of the Floods Directive was tackled in a thematic workshop in Ghent (Belgium) in October 2010 with the title: Floods and Economics: valuating, prioritising and financing flood risk management measures and instruments. The workshop was organised within the framework of the activities of Working group F on Floods of the EU Common Implementation Strategy. This paper is based on the scoping document[2] on flood related economics as issued by the European Commission, DG Environment. The results of the Ghent workshop and of the related questionnaire circulated to EU Member States are included in this resource document on floods and economics. This paper will also serve as a living reference document 'Flood Risk Management, Economics and Decision Making Support' that aims bringing together good practices on flood risk management and economics.

In the Ghent workshop participants agreed on the importance of economic assessments (EA) in the process of flood risk management, both supporting political decisions (policy appraisal) as well as technical decisions (investment appraisal). Economic analysis is not the only instrument, but EU Member States recognise the key role of it in flood risk analysis and in selecting and prioritising measures to manage flood risks. EA can provide reliable information for politicians and stakeholders, and they can justify and explain prioritisation of measures and allocation of resources to execute them. Member States clearly plan to intensify their efforts in this field. There is no unique approach for the use of EA in decision support, and it is recognised that solutions strictly based on economic analysis are not always the best. In some countries cost-benefit analysis is necessary to apply for funding of measures, in other countries it is only used for starting the discussion. The role of EA is limited in case measures would be developed only as a reaction on past floods.

The Council conclusions of 12 May 2011 on integrated flood management within the European Union underline the need for Member States and the EU to take an integrated approach to flood management, encompassing the entire disaster management cycle. Special attention is paid to the use of flood forecasting and warning systems, to cooperation and information sharing between disaster management and water management, also in an international context, to the increasing use of disaster insurance policies with risk-based premiums, to the impact of climate change on these issues, to the development of reference scenarios for floods using risk assessment information, and to the promotion of the use of adequate financial resources. Many of these items are also covered within this document.

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2 Scoping Paper on Flood Related Economics by Arcadis Belgium NV for the European Commission, DG Environment, Project number – 10775, version A, 28-07-2010

2 References to flood risk management related economics in EU legislation

2.1 Floods Directive

The Floods Directive encompasses a number of implicit and explicit references to the use of economics in flood risk management. The explicit references in this respect are:

- Article 7 §3 'Flood risk management plans shall take into account relevant aspects such as costs and benefits; …';
- Annex A.I.5. 'When available, for shared river basins or sub-basins, a methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects'.

These explicit references point out that policy makers are expected to invest the limited resources available in an optimal way. They are held responsible to develop flood risk management plans that have a reasonable balance between benefits and costs. To this end the flood risk management plans need to be underpinned by sound information on its pros and cons; its likely costs and benefits. Keeping this in mind the Floods Directive encompasses some implicit references to the use of economics as there are:

- The concept of flood risk as developed under Articles 2 §2, 6 §5 and referred to in other Articles throughout the Floods Directive[3];
- Article 9 '(…) for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of Directive 2000/60/EC';
- Article 7 §4 'In the interests of solidarity, flood risk management plans (…) shall not include measures which, (…), significantly increase flood risks upstream or downstream of other countries (…)';
- Annex A.I.4 'a summary of the measures and their prioritisation (…), and flood related measures taken under other Community acts (…)';
- Annex A.II.1. 'a description of the prioritisation and the way in which progress in implementing the plan will be monitored'.

The implementation of the Floods Directive was discussed during several workshops organised by CIS Working Group F (WG-F) members in Bad Radkersburg/ Gornja Radgona, Dublin, Brno, Karlstadt, Stirling, Maastricht, Cagliari and Ghent.

The presentation of Mark Adamson in the Ghent Floods&Economics workshop (2010) gave an overview of 'economic topics' in the Floods Directive that were discussed in former WG-F workshops. Although there are issues related to the preliminary flood risk assessment (PFRA) and flood risk mapping, most of the items are related to the flood risk management plans (FRMP). Key point is the difference of level of detail between the PFRA and FRMP.

The relation between economic assessments and the solidarity principle in an international context as stated in article 7, §4 was also discussed in the Ghent workshop.

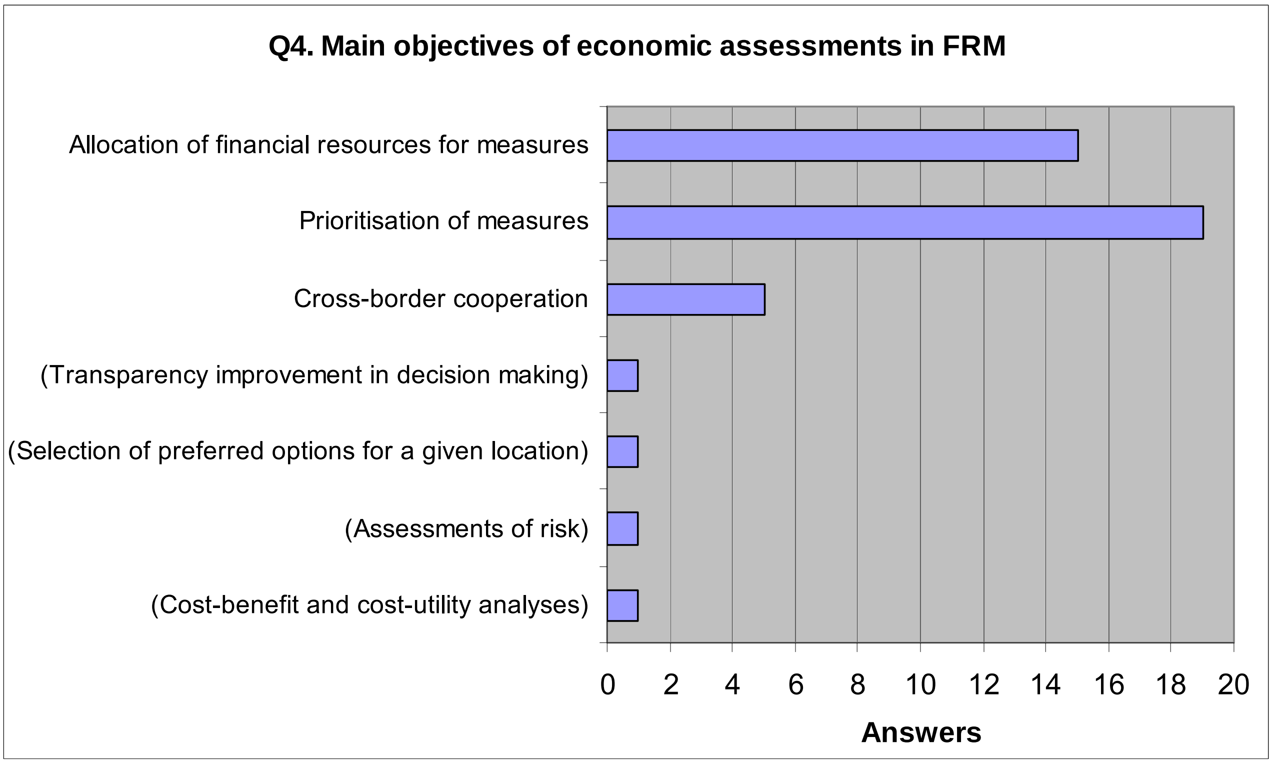
[3] Flood risk is a key concept to determine the likely benefits for society from flood risk management measures and thus for assessing (packages of) measures in terms of their costs and benefits.

Participants agreed that in an international context economic assessments help to understand the different criteria used by Member States (MS) to execute their decision making on goals and measures. This allows MS to agree on differences/analogies in FRM as part of cross-border cooperation. Measures can have positive transboundary influence so we should look upon the possibilities to execute economic assessments along the whole river stretch and for the whole catchment area. The need to coordinate land, water and resource management plans throughout catchments was one of the main themes that earlier emerged during the WG-F workshop in Stirling (2009). An observation in Stirling was that although there is little support for harmonising of methods, it is recognised that benefits, particularly in cross border situations, would be gained from the adoption of consistent principles and approaches. Guidelines on benefit-cost analysis were recommended, paying particular attention to the issue of applying monetary value to environmental and social benefits. The ambition for catchment flood risk management must be supported by practical tools and instruments to aid implementation, with existing and new funding streams aligned to catchment flood risk management objectives, and forums in place to support participation.

Additional remarks related to the solidarity principle were made in Ghent. The solidarity principle applies between MS but also within MS. Risk based management does not necessarily lead to higher safety levels in all areas, even sometimes to lower levels. MS are allowed to use their own set(s) of criteria for cost-benefit analysis. It is questioned if, for transboundary impacts, a set of minimum basic criteria for the community within that catchment should be considered "mandatory". Since finding common criteria for EA to support this principle could be very difficult, it is recommended to exchange good practices in the application of the solidarity principle. An output of the earlier Maastricht workshop (2010) regarding the same item was that the outcome of different cost benefit analysis methods executed within one (inter)national river basin must result in exchangeable or 'translatable' information regarding possible options for (shared) goals and measures between Member States within the river basin.

An important conclusion in Ghent was that economic assessments could deliver mechanisms for compensation of transboundary effects related to the solidarity principle, and cross-border cooperation should be supported by appropriate funding.

The Floods & Economics questionnaire asked for the importance of economic assessments for cross-border cooperation. Only five respondents indicated this item as relevant. On the question regarding Annex A.I.5 of the Floods Directive, asking for the reporting of available methodologies of cost-benefit analysis used to assess measures with transnational effects in shared river basins or sub-basins, it seems that there is no agreement among MS for working on a common methodology throughout the EU for economic assessment of measures with transboundary effects. Most believe that this is very difficult to achieve, but most MS indicate the importance of working on common elements of such a methodology. This is further discussed in point 3.3.



2.2 Water Framework Directive

With increasing scarcity of both water resources and financial resources allocated to the water sector, economic analysis and expertise is increasingly called for in supporting water management and policy decisions. With the Water Framework Directive (WFD), economic principles, tools and instruments are explicitly integrated into a piece of legislation. The experience with the implementation of the economic requirements in the WFD can be of particular help to interpret and implement the references to flood risk management related economics in the Floods Directive.

The WFD aims contributing to mitigate the effects of floods and droughts. The WFD objective is to achieve good status in 2015, notably good chemical status of ground and surface waters, good ecological status of surface waters and good quantitative status of ground waters (WFD Article 4). Good ecological status includes morphological quality elements, and quality elements such as water levels and flow. Some measures to achieve good ecological status may also have the benefit of reducing flood risks; the conservation, protection and, where possible, restoration of degraded wetlands and flood plains contributes both to achieving good ecological status and managing flood risks. Many water bodies across the EU are furthermore classified as heavily modified water bodies due to flood defence infrastructure (WFD Article 4 §3).

Temporary exemptions from achieving the objectives of the WFD and from the non-deterioration principle can also be allowed due *to "circumstances of natural causes of force majeur, which are exceptional and could not reasonably have been foreseen, in particular extreme floods"* (WFD Article 4 §6).

In some instances new modification to water bodies for the purpose of flood risk management, may lead to a permanent deterioration or non-achievement of the WFD objective, but the Member States may be exempted from achieving the objectives if they can provide adequate justifications that there is overriding public interest for e.g. human safety, and that there are no better environmental options available. In this case this needs to be set out in the River Basin Management Plans (WFD Article 4 §7).

Regulation of dams is an integral part of flood risk management, and the WFD includes requirements on the authorisation of impoundments, and the requirement to regularly review these (WFD Article 11 §3(e)). Supplementary measures which may be needed to achieve the objectives e.g. explicitly includes the creation of wetlands (WFD Annex VI, Part B).

The implementation of the two Directives is therefore intrinsically linked and the Floods Directive furthermore lays down that coordination is required in the development of the two sets of plans. Many Member States have already included flood risk management measures in the first River Basin Management Plans (RBMPs) (2009-2015), and the Commission is currently assessing the content of these plans.

The economic aspects of the WFD are therefore also of relevance for the development of flood risk management plans. The key aspects are :

- Economic analysis of water use and review of the impact of human activity on the status of surface waters and on ground water (WFD Article 5, Annex II and III). The latter analysis shall be carried out in coordination with the Floods Directive, by 2013, and shall be reported in the 2015 RBMPs. A first analysis found that flood defences are one of the most important drivers for morphological changes;
- The development of a programme of measures, which in accordance with WFD Annex III shall "*make judgements about the most cost-effective combination of measures in respect of water uses to be included in the programme of measures under article 11 based on estimates of the potential costs of such measures*";
- WFD Article 9 also requires cost-recovery of water services, including impoundments, as defined in article 2, definition 38 of the WFD;
- Public participation in decision making is also required for the WFD (Article 14), and the consultations in the framework of the Floods Directive shall be coordinated with those of the WFD.

The process of developing the first River Basin Management Plans can therefore be a useful source of experience for this report.

The *'Questionnaire on the relevant links between the Water Framework and the Floods Directives - Preliminary survey with WG F'* (2011) describes the possible links between the two directives and asks Member States for their views, aiming to lead to a resource document, a concept paper or a "Frequently Asked Questions" document on this matter.

The presentation of Maria Brättemark in the Ghent workshop gave an overview of the different WFD requirements about economics and the relevant Guidance Documents, and explained the key outcomes from the CIS workshop on WFD Economics that was held one week earlier in Liège (October 2010). The objectives of this workshop were to exchange information and views from Member States and stakeholders on experience in implementing the economic aspects of Article 9 of the WFD and cost effectiveness analysis (CEA), to identify relevant developments and research needs and to identify needs for future work relating to WFD economics. The different aspects of Article 9 implementation included: the cost recovery for water services; definition, estimation and internalisation of environmental and resource costs; the application of the flexibility associated with Article 9 implementation; the application of the polluter pays principle; the adequate contribution of water uses to the recovery of costs of water services and the evaluation of water pricing policies with regards to the provision of incentives for efficient water use in order to reach the environmental objectives of the Directive. Implementation experience of the selection of measures based on CEA was discussed, highlighting the use of expert knowledge and judgement; involvement of stakeholders; the appropriate geographical scale (local, national, regional); the relative difficulty in assessing the effectiveness of measures, rather than the costs; the possible conflict between CEA and the polluter pays principle; the difficulty in applying CEA to a combination of measures. Recent developments in research are the development of ecosystem capital accounts in water, economic valuation of ecological services, the improvement of economic analysis (process-oriented), exploring alternative financing mechanisms by using economic and / or market-based instruments and developments of economic non-market valuation methods and its relevance to the WFD-implementation. An elaborated list of options for future work and upcoming challenges makes clear there are several open issues where FD and WFD can be linked.

Ann Kathrin Buchs also gave a presentation on this topic: Economic Assessment for Implementing Flood Risk Management – case study of Lower Saxony – lessons learned from WFD (full paper on CIRCA). These lessons learned show that the WFD requirement for economic assessments as e.g. the cost-efficiency of measures has to be approached in a broader context, not only with the application of theoretical methods as the cost-benefit-analysis. The constitution of institutions, structures and processes and the mechanisms that influence their actions play an important role to support and ensure an efficient outcome of economic assessments. The presentation contains several ideas for further proceeding.

In the Ghent workshop, participants recognised that both directives (FD and WFD) are interlinked and cannot always be looked at separately. Institutional integration between the competent authorities of both directives helps identifying synergies, including in economic assessments, which is easier for small size countries. Institutional cooperation should be improved, with more focus on a strategic view on the synergies between the two directives.

Two difficulties in finding synergies were raised: the fact that the beneficiary of flood risk management is less easy to identify than the traditional water service user, and the fact that some flood risk related measures can have positive effects on WFD objectives, while others will have adverse impacts. This can also be looked the other way around: WFD objectives could hamper the development of appropriate FRM measures.

Synergies between art. 5 of the WFD and art. 6 of the Floods Directive should be maximised to optimise coordination, and information and experiences with this coordination should be exchanged. In doing economic assessments for the Floods Directive, WFD aspects should be taken into account. Synergies can be found in hydromorphological measures and natural flood risk measures.

Floods are natural events, so positive effects on ecosystems have to be included in economic assessments. Working on measures with multiple benefits makes it easier to find funding and to avoid conflicts between the two directives. Strategic Environmental Assessments can indicate the impact of flood measures on the ecosystem. A more straightforward way to indicate co-benefits between the FD and the WFD is the inclusion of ecosystem services in the economic assessments of flood risk management. The acceptability for taking into account value of ecosystem services should be increased. Sustainable urban drainage systems (SUDS) can be looked at as good practice for multiple synergies..

3 Floods and economics decision framework

3.1 The effects of floods on the society

Floods can be considered as a shock in the evolution of society on the path of sustainable development (Green et al., 2011). The measure for sustainable development is well-being which is a broader concept than economic welfare. Well-being is an all-encompassing and multi-dimensional conceptualisation of what a society seeks to achieve. The criteria for well-being can be expressed in economic terms (e.g. GDP), social terms (e.g. human health), environmental terms (e.g. existence and health of natural habitats) and cultural terms (e.g. cultural heritage sites). Vulnerability is a measure for the drop of well-being at the moment of a flood, and resilience is a measure for the speed to recover from the flood to the former level of well-being.

The ability to recover from a flood is mostly regarded within a short-term time perspective. Floods tend to induce however, during a response phase, reaction of the society (water and land managers, affected people, companies, politicians etc.) aiming to perform better than before. When they choose to take action in the fields of prevention, protection and preparedness within a strategy of sustainable development, this reaction can lead in the longer term to a higher level of well-being. As a consequence the overall strategy of flood risk management should focus on enhancing both immediate as well as long-term resilience and aiming at higher levels of well-being for the society.

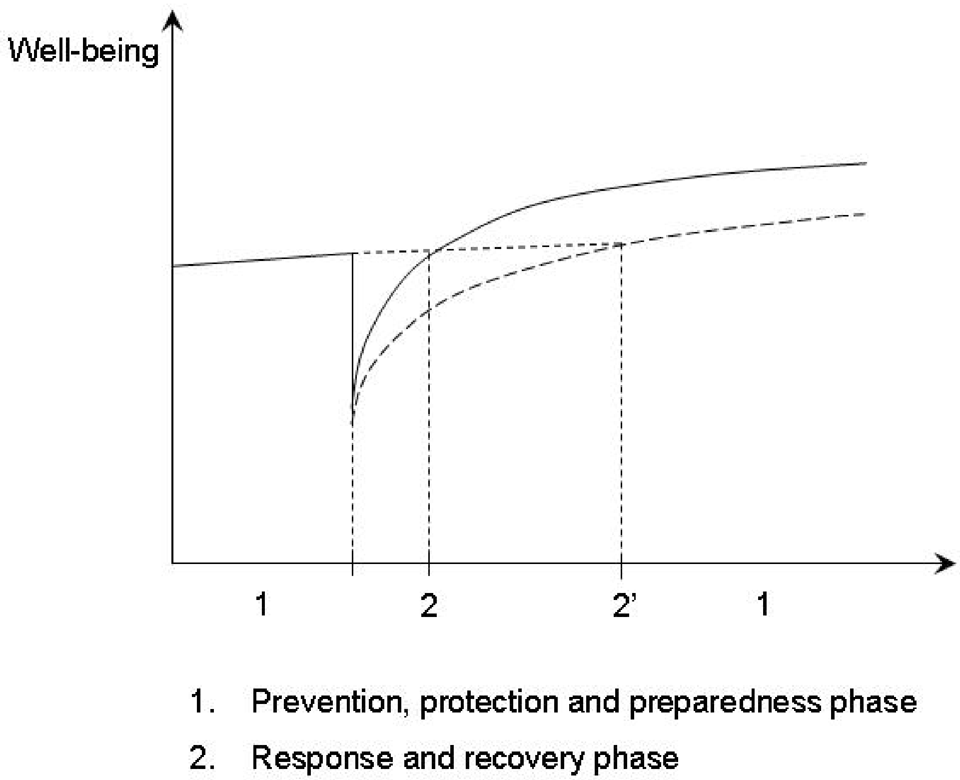


Figure 1. The effects of floods on the society

3.2 General decision framework

Flood risk assessment, as required by the Floods Directive in the preliminary flood risk assessment phase and in the Flood Risk Management Plans as further explained in point 4.1, is a key concept to determine the likely benefits for society from flood risk management measures and thus for assessing (packages of) measures in terms of their performance to reach higher levels of economic welfare (when economic benefits exceed the costs), and of human health, environmental and cultural values. Comparing flood risks over time, between different regions and for different (packages of) measures, requires specific assessment methods, an adequate decision framework, defining a common baseline, accounting for the time value of money, etc. Maximising synergies between flood risk management measures on the one hand and the (programmes of) measures proposed in the framework of the Water Framework Directive on the other hand implies also considering specific non flood risk related costs and benefits of measures.

The general decision framework to evaluate ex ante flood risks and measures to reduce the risk is meant as a support for the decision processes in flood risk management. Economic assessments are in most cases only part of these decision processes. The framework is a methodology requiring data and methods to be applied. The methodology is not standing on its own, but has to be embedded within a process of discussion with stakeholders and decision makers. Final decisions on optimisation and prioritisation of measures are always a combination of both technical and political elements taken into account.

The decision framework requires data and outcomes of calculations, both technical as well as economical, requiring a multidisciplinary approach engaging engineers and economists. Databases and models are to be fed with information from surveys, GIS data, ex post evaluation of past flood events and experience from flood risk managers. Typical requirements are hydrologic and hydraulic models of the watershed and the river, a digital terrain model, land use data, a database of damages, depth-damage functions etc.

Examples of different flood hazard and flood risk maps, including vulnerability and damage maps, transboundary flood hazard maps, insurance maps and evacuation maps can be found on the website of the EXCIMAP project. More information on data and tools requirements can be found in different reports of the Floodsite project, the ConHaz project and others.

General decision framework for identifying, assessing, evaluating and prioritising measures

1.Defining an appropriate baseline, accounting for climate change and both land use and socio economic changes. This is further explained in point 3.2.

2. Analysing flood hazards, as explained in point 4.3.1.1.

3. Analysing the value and vulnerability of the receptors considered (see point 4.3)

4. Calculating flood risks (see point 4.4)

5. Identifying flood risk reduction measures

6. Analysing the impact of flood risk reduction measures on flood hazards and the value and vulnerability of the receptors considered

7. Calculating flood risks with flood risk reduction measures

8. Calculating flood risk avoided

9. Analysing costs and non-flood risk related costs and benefits

10. Evaluating and prioritising measures

Identifying optimal measures is an iterative process and may require to run several times through the decision framework.

A valuation framework should start with cost-benefit analysis. Along the process criteria can be added which cannot be captured in monetary terms and hence interpreted with multi-criteria analysis (Meyer et al., 2012).

Recital 18 of the Preamble of the Floods Directive points out that 'A significant challenge exists in striking the balance between devising methodologies that allow for a robust assessment of alternative measures, while at the same time not being excessively costly, technical, or prohibitively complex for interested parties to understand.' This implies that the decision framework for evaluating and prioritising flood risk management measures and drawing up flood risk management plans should be kept relatively simple although still allowing for a consistent assessment. Questionnaire respondents agreed that the applied concept of risk should run through the process of hazard and risk mapping, the setting of objectives and the definition and prioritisation of measures to reduce the flood risks.

A conclusion of the Ghent workshop was that not all aspects of economic assessments are purely scientific, some have to do with policy choices. It is recommended however that the built-up decision framework, as well as measures already decided based upon this framework, should be kept over a longer period, regardless of changes in political direction after elections.

Some Member States have implemented national guidelines for economic assessments in flood risk management. Questionnaire results (Q6) are compiled in Annex 1. Besides national guidelines, some MS implement international guidelines, especially when they relate to EIB loans.

Questionnaire results (Q10) also delivered references to projects where economic assessment was important for decision making.

Reference can be made to the requirements of the Environmental Impact Assessment Directive for the evaluation of specific projects.

3.3 Principles of good assessment

3.3.1 Building an appropriate baseline

A baseline is an actual or assumed situation used to set out current and future risks against which one or more flood risk reduction measures or management plans are compared. It is essential that an appropriate baseline is identified. The description of the baseline has to be tailored, in extent and scope, to the risk management problem being examined.

For carrying out a CBA the do nothing option is often used as the baseline. Even when doing nothing society evolves. Both the economy and the population grow, land use changes, the WFD and other regulations increasingly limit the adverse effects of human activities on the environment, but the pressures originating from human activities are beyond the carrying capacity of the earth triggering e.g. climate change. As a result flood risk is expected to even increase. The reason for this is mainly twofold. Firstly, climate change is likely to increase the magnitude and frequency of floods because of the expected increase in extreme rainfall events on the one hand and sea level rise on the other hand. Secondly, there is also a marked increase in the number of people and economic assets located in flood risk area.

Ghent workshop participants agreed that future scenario's for FRM (climate change, land use change, population growth, wealth growth,…) should be taken as basis for reaching objectives, instead of reaction on past events. To take into account future scenario's there is a need for data to monetise or quantify them, otherwise assessments on qualitative level are necessary. There are doubts if floods could have long term effects on competitiveness.

More than half of the questionnaire respondents indicate to use climate change scenarios in their assessments and projections of future flood risks. References to examples are indicated in Annex 3.

Some MS take land use change (new developments, agricultural changes etc.) and wealth growth scenarios into account, but in many cases these aspects are only looked at on a strategic level (like in PFRA) or are still in an experimental phase and not yet operational.

Global climate policy scenarios for 2030 and beyond can be found on the JRC website.

There was a remark that those considering individual FRM projects are discouraged from forecasting land use changes, because of the potential for measures only to be justified in the event of further development of the flood plain, which is regarded as undesirable.

3.3.2 Setting assumptions

The desirability of a single flood risk reduction measure, and consequently also the outcome of the evaluation of alternative flood risk management plans, may differ much depending on the assumptions made. Setting the appropriate **time horizon** and **spatial boundaries** is crucial for a sound assessment as it is important to include all important impacts. On a strategic level the spatial boundaries of a flood risk management initiative are often those of the entire catchment in order to allow for an integrated solution. For what concerns the assessment of the flood risks it may not be sufficient to only cover the inundated area because indirect effects like disruptions of transportation and production may sometimes be felt outside the inundated region. Similarly, in the choice of the time horizon it should be preconceived that some flood consequences like health or environmental effects might require the consideration of time spans which are longer than those normally applied for typical material damage categories. Besides, as climate change may alter flood patterns and intensities significantly it may be important to extent the time horizon considerably in order to account for the likely impacts of climate change. The guide to cost-benefit analysis of investment projects of the European Commission argues to gear the horizon for the analysis to the planned useful life of the investment (usually 50 years). The HM Treasury (2003) recommends to account for a 100 year period in order not to neglect impacts that would be harmful in the long term. Such an horizon is quite consistent with climate change projections that often provide forecasts up till 2100. (Florio et al., 2008; HM Treasury, 2003; Messner et al., 2007)

Participants of the Ghent workshop however stated that a time frame of 100 years is too long for policy objectives or life span of measures, so a time frame of 50 years would be more appropriate. In the case lifetime of investments would be longer than 50 years, the rest value of investments can be taken into account.

A second issue concerns the weight to give to gains and losses that occur at different moments in time. Discounting is used to bring the stream of future costs and benefits to a common base date. A cost or benefit that occurs in one year's time is therefore treated as having a lower real value now than an identical benefit today. This has to do with both the opportunity costs of capital as well as people's preferences for benefits today rather than benefits tomorrow. The time value of money is reflected by the discount rate which is used to bring a stream of costs and benefits to a base date. There, however, is no real consensus among economists about what discount rate would be appropriate. Discounting often causes discomfort. Therefore a social discount rate may be used which reflects the social view on how future benefits and costs should be valued against present ones. The discount rate used may be fixed or preferably decrease over time4. Dealing with the problem of intra- and intergenerational equity using discount rates is discussed in the Guideline for economic effects and evaluation in EIA.

An appropriate way to deal with the problem of discounting is to apply several discount rates in the analysis in order to consider their impact on the results and to include this knowledge in the final decision. This actually comes down to conducting a sensitivity analysis, which is discussed under title 3.2.5. (Messner et al., 2007)

Ghent workshop participants concluded that the choice of the discount rate (3.5 or 4%, decrease after x years or not,…) has in practice a much higher influence on the outcomes of economic assessments than the selection of the time frame.

3.3.3 Counting economic losses

Where financial evaluations look at the impacts a flood risk reduction measure or management plan may have on a single actor, economic evaluations look at the economic welfare of a region or country, including intangible impacts. This broader economic perspective is better suited to apply for supporting public policy decisions. In practise this comes down to making sure receptors are attributed the right values. The

[4] HM Treasury (2003), Commissariat Général du Plan (2005), Florio et al. (2008), Messner et al. (2007), Penning-Rowsell et al (2005b), ISDR (2009)

real value of a market good corresponds to its scarcity price. A scarcity price emerges in the context of an ideal competitive market with many competing actors involved and without government intervention. Since these ideal conditions are never fulfilled in a real-world market, adjustments are necessary in order to calculate the ideal shadow price of the receptor under examination. This means, real world market prices must be translated into shadow prices by excluding all kind of transfer payments, taxes and subsidies and by converting monopolistic market prices into competitive market prices. (Florio et al., 2008; Messner et al., 2007)

Some practical implications related to the relativity of values can be found in the CONHAZ project report “Guidance for assessing flood losses”. (Green, C., Viavattene, C. and Thompson, P. ,2011)

“Conventionally, the loss of or damage to assets in a flood are called the 'direct damages'. Their magnitude is relevant as a measure of the shock to the system. But there is no clear relationship between magnitude of this shock and the immediate reduction in well-being or the subsequent trajectory of the system. If the direct damages were instantaneously replaced then this distinction between physical losses and lost of well-being would be almost irrelevant, because the trajectory would be unchanged. But the resources to replace those losses would have to be diverted from other uses and so either current consumption or future consumption or growth in consumption would have to be sacrificed. Each response will have some effect upon the trajectory of the system. In general, it is likely to be preferable for the long term to sacrifice some current consumption, and thus to sacrifice current well-being, in order to enable the replacement of lost assets.

There are two issues which can affect the degree to which assumptions of linearity and additivity will give serious errors: proportionality and additivity. For additivity, it would require, for example, that a loss of €20 million of housing, €20 million of televisions, or €20 million of schools all have exactly the same effect. But it would not be unreasonable to expect that the loss of €20 million of televisions would have a relatively minor and transitory effect whilst the loss of €20 million of homes would cause a loss of wellbeing for a substantial period of time; and the loss of €20 million of schools might result in the permanent reduction in educational attainment of the affected children. Again, suppose there were a loss of €20 million of flour and €20 million of bakeries; because the bakeries are out of action, the €20 million of flour could not be turned into bread.

The second example can be extended to illustrate the problem of proportionality: a loss of €20 million of bakeries from a total asset value of bakeries of €200 million is likely to have a more severe effect than a loss of €20 million of flour from annual production of €2 billion.” (p.57-58)

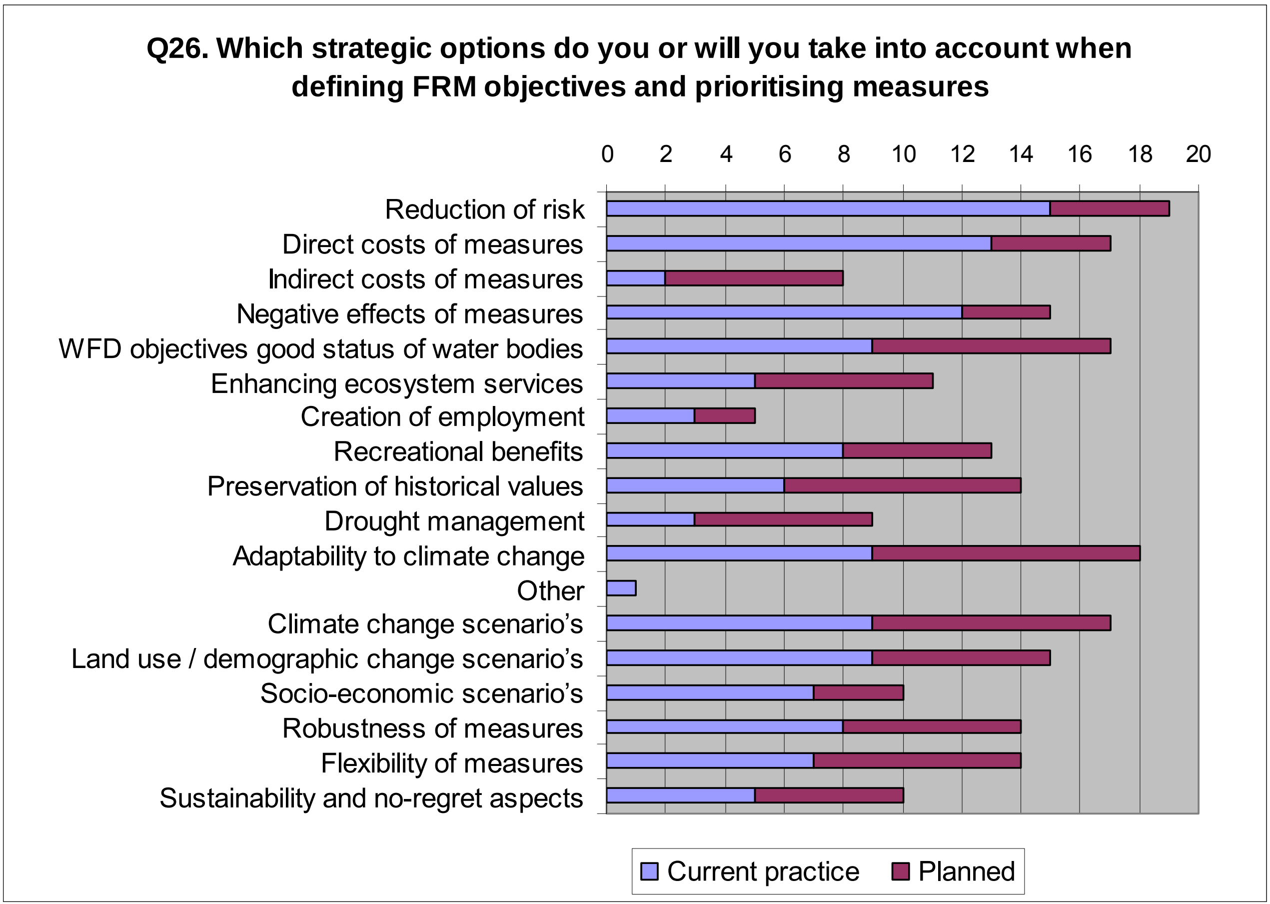
3.3.4 Accounting for non flood risk related effects

Deciding between different flood risk reduction measures or management plans should not only be done on the basis of the impact on flood risk on the one hand and the financial costs of the corresponding flood risk reduction measures on the other hand. Flood risk reduction measures may also generate non flood risk related effects; which may be both positive and negative. If these are relatively important these should be taken into account. (Brouwer and van Ek, 2004; Florio et al., 2008; De Nocker et al., 2007; Gauderis et al., 2006)

As an example, the construction of areas for controlled flooding may require the expropriation of land and houses. The construction of extra dikes may hamper the view of the houses located close by. People's properties may also be confronted with a rise in the water table. An area for controlled flooding may, however, also offer opportunities for creating/restoring ecological values, at least if water quality is fine. Tourism and recreation may benefit as well. (Brouwer and van Ek, 2004)

Section 4 of this document looks at different kinds of consequences and how to take them into account.

The floods & economics questionnaire asked for the different strategic options that Member States take into account for defining FRM objectives and prioritising measures. Many respondents are still working on the methodology to assess risk, to define objectives and to prioritise measures, but apart from risk reduction most MS indicate that they already work on or plan to work on costs and benefits of measures. A majority of MS (12) already takes direct costs of measures into account. Indirect costs are rarely taken along. After risk reduction and costs of measures, the most important criteria are possible negative effects of measures, reaching WFD objectives and adaptability to climate change, the latter two mainly based on planned initiatives. For long term criteria, MS indicate climate change and land use change scenario's as being the most important.



3.3.5 Sensitivity and uncertainty analysis[5]

A sensitivity analysis is used for identifying the 'critical' parameters/values. A critical parameter is a parameter for which small variations, positive or negative, in the parameter value have a relatively important impact on the performance/outcome of a flood risk management measure or plan. A sensitivity analysis does not require information on the degree of uncertainty of any input parameter. Consequently, the resulting information only provides an insight into the robustness/variability of the results.

The ex-ante assessment of flood control scenarios is not without problems. The outcome of an assessment is always uncertain to some degree. There are different types of uncertainty. With regard to the ex-ante appraisal of flood risk management measures or plans the following sources of uncertainty exist:

- Uncertainties in the knowledge of economic, social, ecological and physical systems;
- Shortcomings in the way the economic, social, ecological and physical systems are modelled and, finally;
- Data limitations.

Tracking uncertainty is important for facilitating sound decision making. It should provide the decision maker with an idea of how confident the results are. Uncertainty analysis can be broken down into three phases:

- Identification of the various sources of uncertainty
- Quantification of the uncertainties identified
- Reassessment and discussion of the results in the light of uncertainty

The identification of the various sources of uncertainty is often relatively straight forward. Interactions between the various sources of uncertainty are generally well understood, but the problem is to really quantify the uncertainties identified. More efforts should be directed to the quantification of uncertainties. Priority should be given to those uncertainties that are either easy to eliminate or are most important in the overall result. Some of the uncertainty about flood risk management is related to the effect of climate change. This item was also raised at the WG-F workshop on Climate Change in Karlstadt (Sweden). To make real progress in this respect there is a need to improve climate models and scenarios at a detailed regional level, especially for extreme events. Also changes in land use are a high factor of uncertainty within the time horizon of 50-100 years. Once the relevant uncertainties have been quantified their influence on the outcome of the assessment can be evaluated. To this end one could e.g. make use of Monte Carlo analysis.

Ghent workshop participants concluded that uncertainty is inherent to decision making and looking into the future. This should be highlighted to policy makers. It is recommended to decrease the uncertainties in economic assessments in order to cope with critics of the public, because the principle of cost recovery will become necessary for future financing instruments.

5 Based on: Florio et al. (2008); Gauderis et al. (2006); De Smet (2010b)

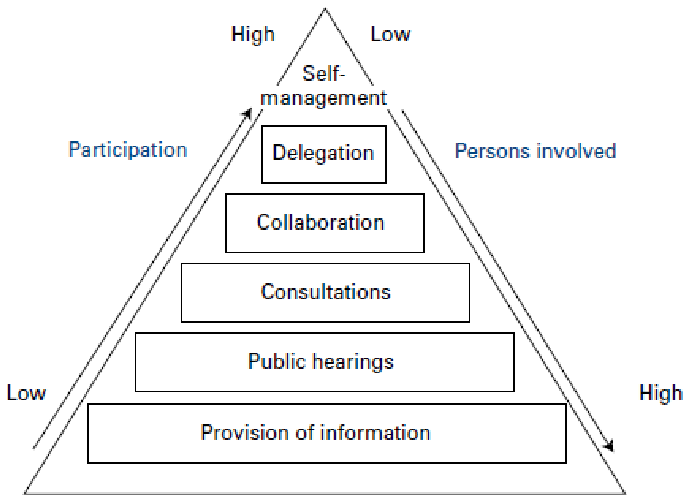
3.3.6 Stakeholder participation[6]

Stakeholder involvement is critical in flood risk management in order to make sure the right decisions are taken, maximising welfare. Water managers need to know how the public perceives the flood problem, what action the public requires them to take as well as how the public values both the way and the extent to which the proposed flood risk reduction measures or management plans reduce the flood problem. Eliciting this information from the public requires fully informed stakeholders in order them to provide the correct information to the assessors throughout the entire appraisal process. Stakeholder involvement is most crucial when:

- Defining the flood problem;
- Setting objectives;
- Identifying flood risk reduction measures or management plans;
- Assessing the impacts of flood risk reduction measures or management plans;
- Evaluating and prioritising the proposed flood risk reduction measures or management plans.

There are various participation methods with varying degrees of stakeholder involvement: provision of information, public hearings, consultations, collaboration in decision-making and delegation of responsibilities, as illustrated in Figure 1. The greater the extent of participation and control over decisions, the lesser the number of stakeholder representatives engaged in the process.

Figure 1 Levels of stakeholder participation



Source: World Meteorological Organisation (2006a)

At the basin level, decisions regarding the degree of risk that people are prepared to take and pay for must be decided. By involving the stakeholders' ethical considerations

[6] Based on World Meteorological Organisation (2006a and 2007). Interesting insights were also presented at the WG F workshop in Maastricht, 26 – 28 January 2010.

regarding equitable development, distribution and sharing of risk and decisions as to who should finance flood risk mitigation can be made.

Having defined the problem and set the objectives it is possible to identify those flood risk reduction measures that would best meet the objectives set. Depending on the evaluation framework used the focus of stakeholder participation tends to be either more on the assessment of the impacts or on the evaluation and prioritisation of the proposed flood risk reduction measures or management plans.

Since evaluation involves social values, it would be quite appropriate to carry out CBA or MCA in conjunction and close consultation with and participation of the public affected. The opinion of the public may be sought at different stages in the CBA/MCA exercise. The first inclusion of local values in the CBA or MCA process comes at the scoping stage, resulting in selection of the more important impacts for further study. The public may also be invited to give comments on a CBA or MCA worked out by experts whether with or without public participation. These comments should be taken into account while finalising the CBA or MCA.

When conducting a full CBA the evaluation and prioritisation of the proposed flood risk reduction measures or management plans is simply about adding all costs and benefits; participation has taken place when assessing the impacts. The impacts need to be assessed in monetary terms. The value component of a particular impact can be assessed using revealed preference approaches which are based on observed economic behaviour. When the importance of an impact is less clear as the good or service affected is not traded in markets or not closely related to any marketed goods stated preference approaches can be used to directly measure people's willingness to pay by means of surveys. The qualification or quantification of the impacts that precedes their monetisation may also require stakeholder participation. Much depends on the methods and the data that is available.

Likewise stakeholder participation may also be needed for the qualification or quantification of the impacts to be fed into the decision matrix of a MCA. Stakeholder participation in MCA can be attributed an important role during the actual evaluation and prioritisation of the proposed flood risk reduction measures or management plans. The impacts are not comparable yet as they are all expressed on various scales. The integration of the different impacts is very critical for the overall outcome of the analysis and requires to assess the importance of the standardised scores for each decision criterion. This may be a complex task. Stakeholder involvement in this process should promote sustainable decision making by discussing on possible weights of the evaluation criteria and making the evaluation of alternatives more open and transparent. MCA is used to rank different options, but does not say whether the benefits of a particular flood risk reduction measure or management plan would outweigh the corresponding costs. In order to partly overcome the limitations of MCA in this respect one could define the point where costs become disproportionately high. The public may be involved in this assessment.

Irrespective of the fact a particular flood risk reduction measure or management plan is believed to yield the highest benefit to society as a whole the distribution of the costs and benefits may be important too. The equal distribution of the costs and benefits may be one of the decision criteria in a MCA. A CBA framework is less appropriate to account for this extra dimension of the decision problem. In certain cases it is possible to adjust a CBA for the unequal distribution of costs and benefits by weighing the costs and benefits to more vulnerable people differently from those that are more well-off. It is clear that providing all stakeholders, including the public, with full opportunities to share their views and influence the outcome is important to create a general support for the outcomes.

Stakeholder participation was also discussed in the Ghent workshop. The use of maps reflecting hazard, vulnerability and risk is important for communication with the public, but they should not be too complicated and easy to understand for the public. These maps should focus on the areas of potential significant flood risk. Detailed information is not always available. People are mainly interested whether their property will flood or not, so a minimal level of detail is necessary. It is important to show comparable numbers (like numbers of houses and people affected), and they should be harmonised as much as possible. Stakeholders can discuss on relative weights of criteria in the decision frameworks, but it is questioned that it always leads to an acceptable outcome. In communicating criteria and results, the number of parameters should be minimised, e.g. to the 4 types of impact (economic, social, environmental, cultural).

In the WG-F thematic workshop Stakeholder Involvement in Flood Risk Management (Bucharest, Romania, 17-18 April 2012), especially in session 3 "Preparation and implementing FRMP – involvement of the public and local stakeholders" the issues of stakeholder participation and the use of methods like multi-criteria and economic analysis for setting objectives and selecting flood risk management measures were further discussed.

3.3.7 Robust, flexible, no regret measures and strategies[7]

Aiming at an optimal level of flood risk is not straightforward. Uncertainties about e.g. the preferences of the public, the impact of climate change, synergies with the objectives of the water framework directive, etc. may remain important. Keeping options open for the future may be important. This is not only because uncertainty may be too high to take drastic decisions, but also because financial resources may be too limited in the short run. It therefore is essential to seek:

- Robust strategies that perform reasonably well compared to alternative strategies across a wide range of uncertainties including plausible socio-economic and climate scenarios;
- Flexible strategies that can evolve over time in response to long term changes or new information;
- No regret measures of which the benefits exceed the corresponding costs whatever the extent of future climate change and other important evolutions;
- Win-win options that have the desired result in terms of minimising the flood risk, but also have other social, environmental and economic benefits.

3.4 Assessment at different levels

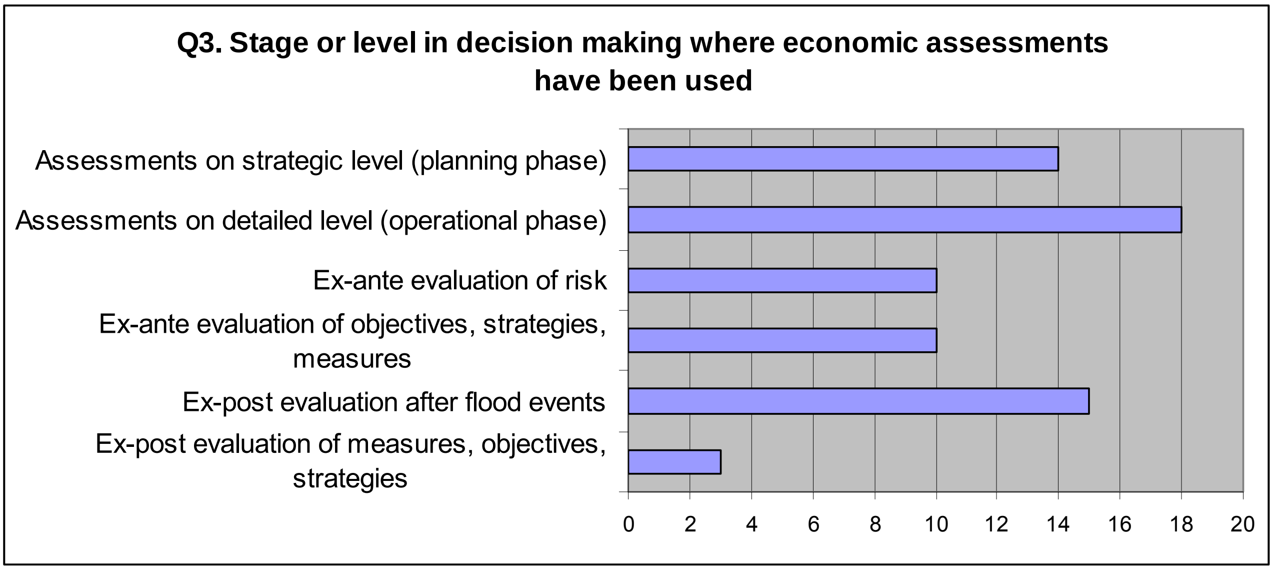
Assessments on river basin district level (for the purpose of the development of flood risk management plans) and assessments on local level (for the purpose of assessing

[7] Based on European Commission (2009); Giron et al. (2010)

individual measures in terms of selection, location, dimensions etc.) differ. The focus of both assessments is different. The former is rather about establishing the main lines, the overall strategy and principles while the latter type of assessment is much more operational, aimed at studying local (alternatives for) projects. As the focus of these assessments varies both also do have their own specificities. While elaborating the best flood risk management strategy (what mix of measures to take forward at the different locations?) the overall picture has to be clear. The scale of the plan or the project, the desired level of accuracy, the availability of data and of resources, they all will lead to a different approach for the assessment (Messner et al., 2007). Irrespective of the scale of the assessment the principles of good assessment need to be taken into account (building a proper baseline, counting all important (side)effects both positive and negative, etc.). Local scale assessments need to be consistent with those at a higher level, taking forward the assumptions and principles already agreed on. This is especially true in an international context. For transboundary cooperation it is important to be aware of the differences regarding applied methods, data availability, etc.

A lot of strategic choices have to be made before individual (packages of) measures are to be identified, elaborated, assessed, evaluated and prioritised. Experience with economic assessment on the local level can, however, feed and support strategic decision making at a higher level. It is the objective that this document provides tools and insights for supporting the assessment of flood risk (management plans) at different levels.

The Floods & Economics questionnaire revealed that most Member States (18) use economic assessments up to now mainly for analyses on detailed level, in the design or operational phase of measures, but many MS (14) apply also economic assessments on a strategic level in the planning phase of flood risk management plans. The two step analysis to calculate avoided risks as part of the general decision framework is not (yet) operational everywhere. Only 10 answers refer to ex-ante evaluation of risk, 10 to ex-ante evaluation of FRM objectives and strategies or planned FRM measures, and 3 to ex-post evaluation after realisation of FRM measures, objectives or strategies. A majority of 15 respondents use economic assessments in the ex-post evaluation after flood events.



The Ghent workshop participants recommended to make use of economic assessments on strategic level to reach the best mix of measures, meaning the right balance of prevention, protection, preparedness, response and recovery measures, depending on the physical and social context. Flood risk management plans (FRMP) should be the framework for these strategic decisions. FRMPs will include many different types of actions including non-structural measures, and the limited experience with economic assessments of non-structural measures is a difficulty to overcome. In addition, many floods on local level are difficult to assess economically on strategic level of FRMP (e.g. pluvial floods may happen anywhere and at any time). It was also concluded that economic assessments on strategic level are able to support protection of non-developed flood prone areas under high spatial pressure, induced by preferences of living in the countryside and in the neighbourhood of water, and industrial or harbour developments. Prevention of inappropriate development is also essential in order to safeguard downstream areas from flooding. If there is no possibility for legal constraints, at least guidelines for land use planning should be developed.

Example of transboundary cooperation for the river Scheldt

The aim of the Sigma plan for the river Scheldt is to increase the safety by decreasing the flood risk. At the same time, navigation to the Antwerp harbour is very important. The flood damages and risks are quantified and monetised. Recreation and nature development as well as climate evolutions are important and are expressed in a social cost benefit analysis for different alternatives of measures. Transboundary effects in the Netherlands and Belgium (Flanders) are in the same analysis. For scenarios with a storm flood barrier, a controlled link in between Westerschelde and Oosterschelde, dike heightening and different alternatives under the topic ‘space for the river’ (including controlled overflow zones, wetlands and reduced tidal areas) the costs are defined. Costs are the sum of investment costs and maintenance and working costs and are expressed over the whole lifetime of the measure. The benefits for safety are expressed until 2100 and have the same discount rate as the costs. Taking into account the other effects (oil 2100 as well): navigation, agriculture, view of people living in the neighbourhood, nature, recreation possibilities etc. the total net actualised benefits of the different alternatives are expressed in monetary terms and in time (years) to recover the costs. For the Sigmaplan the optimal solution is a combination of dike heightening, controlled overflow zones (where the actual land use can be maintained) and wetlands and reduced tidal areas. A step by step optimising procedure will systematically screen all possible combinations and alternatives (www.sigmaplan.be or www.vnsc.eu).

4 Methods for the assessment of values affected by flooding, their vulnerability, the consequences arising from floods, and flood risk

4.1 The concept of flood risk[8]

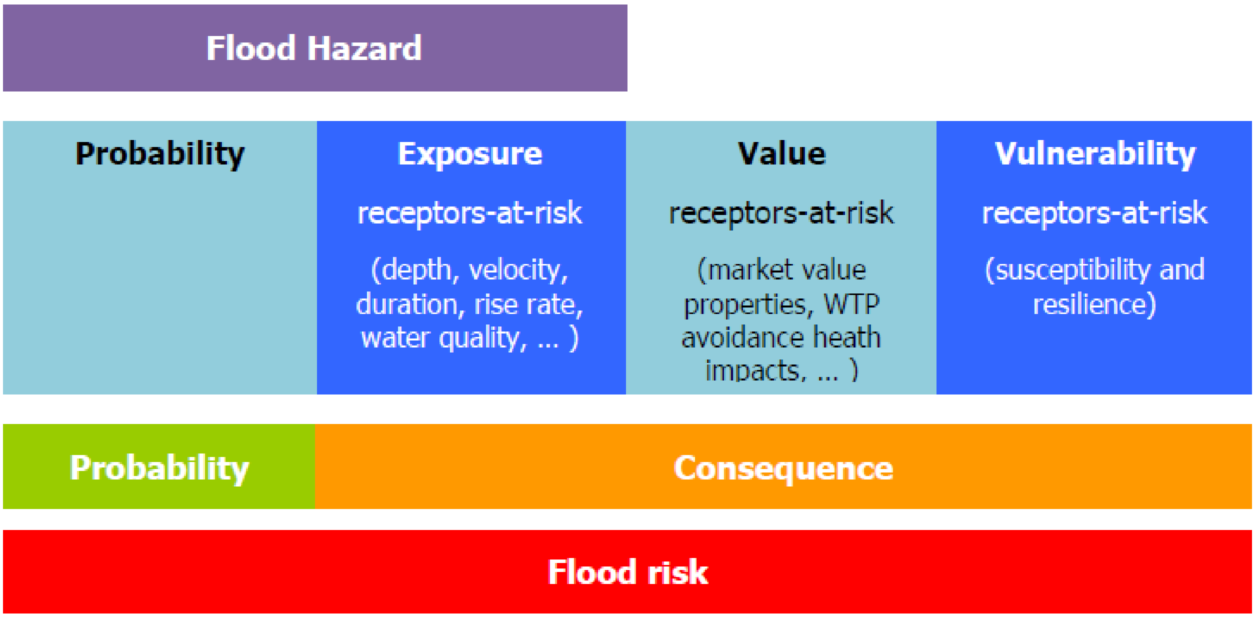
Article 2 of the Floods Directive states that flood risk means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event. During the WG-F workshop in Dublin the following questions regarding this definition were raised:

- How can social and environmental risks, and risks to cultural heritage be measured (i.e., what indicators of risk might be appropriate)?
- Can, or should, social and environmental risks, and risks to cultural heritage be monetised, and if so, what would be the benefits of doing so?
- Information exchange and joint research should be undertaken to permit / enhance the calculation or estimation of the impacts / consequences of flooding (i.e., receptor vulnerability and risk analysis), with respect to significance of flood risk (PFRA), detailed risk assessment (FRMP), setting of objectives (FRMP) and justification and prioritisation of measures (FRMP). This is particularly relevant with respect to social and environmental risk, and risk to cultural heritage and infrastructure receptors.

Flood risk captures the impact flooding has on society. The concept of flood risk, which is function of the probability that a flood event will occur and the consequence associated with that event, is crucial when considering flooding in a policy context. Practically, flood risk is made up of four major building blocks: the probability of flooding, the exposure of the receptors-at-risk to a flood with certain characteristics, the value of these receptors-at-risk and the vulnerability of these receptors-at-risk. The combination of the first two components gives the flood hazard while the combination of the latter three elements constitutes the consequence of flooding. Figure 2 Components of flood risk provides a schematic overview of the different components that make up flood risk.

[8] Based on: Messner and Meyer (2005); Gouldby and Samuels (2005) and Giron et al. (2010)

Figure 2 Components of flood risk



Based on (Messner and Meyer, 2005)

Information on both the probability and the exposure is embedded in flood maps. The most relevant flood characteristics for determining the impact from flooding are depth, velocity, duration, rise rate, period of occurrence and the water quality.

The assessment of the value of the elements-at-risk is generally less obvious. The elements-at-risk are not always of a direct tangible nature. Consequently, the value society holds for preventing elements-at-risk to be affected can not always be easily determined. The concept of value goes beyond the narrow concept of financial value and also accounts for effects to the functioning of social and ecological systems which are much harder to quantify, let alone monetise. In particular the assessment methodologies for the social, cultural heritage and ecological impacts are confronted with this burden.

The vulnerability of the receptors-at-risk is a function of their susceptibility and resilience to flooding. In case a receptor-at-risk is not susceptible it will not be adversely affected / damaged even when it is flooded. The resilience of a receptor-at-risk points at a receptors' capacity to recover from the adverse impacts from flooding.

Over time the receptors-at-risk can adapt to the effects of flooding. Adaptation may lead to a decrease of the value-at-risk, an increase in the resilience of the receptors-at-risk as well as a decrease in their susceptibility. The degree to which adaptation effectively takes place depends on the adaptive capacity of the receptors as well as the awareness for the flood problem.

Ghent workshop example of risk assessment in Ireland

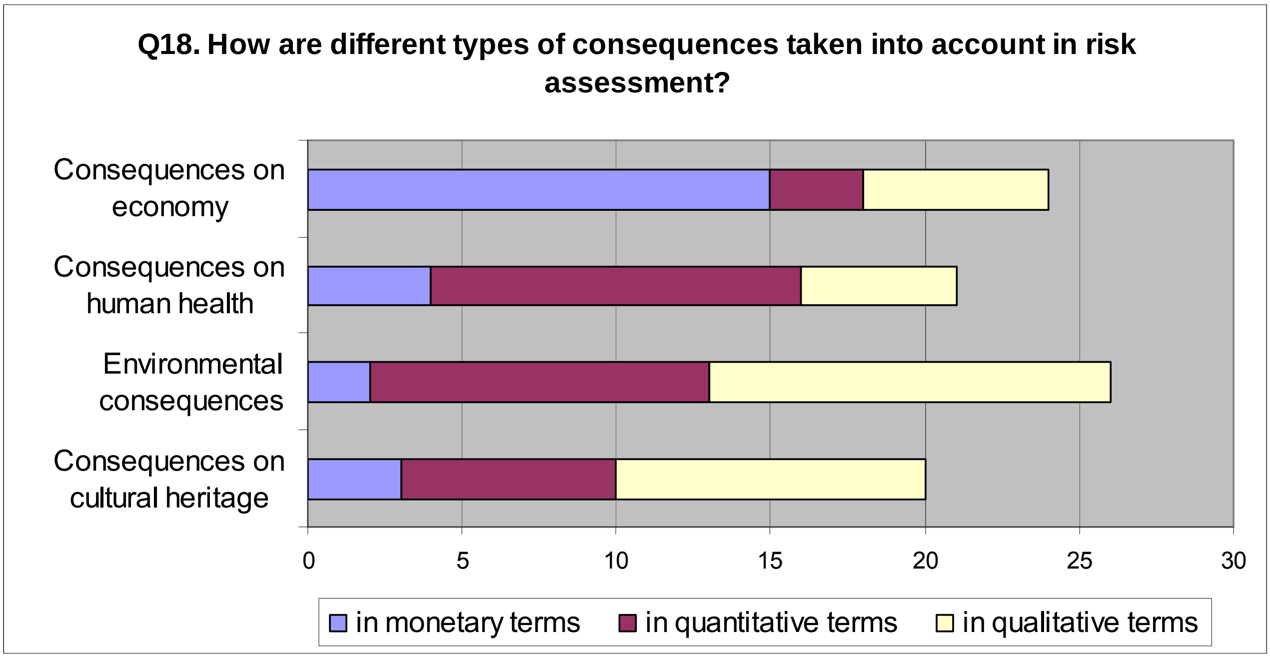
In the Ghent workshop, Mark Adamson (OPW, abstract 5 and full paper) gave a presentation on vulnerability and risk assessment for the PFRA in Ireland. A first part of the presentation gave an overview of the different flood risk receptors in the stage of the PFRA. The second part was the approach for the vulnerability assessment which is partly subjective but standardised and subject to discussions with experts. For each receptor the importance and susceptibility to damage is defined. In a third stage a risk assessment is done for the individual receptors and cumulative in the areas of risk. The last part describes the Irish methodology and thresholds for the relevant and important topic of 'significant' flood risk together with some preliminary results of application.

Ghent workshop example of risk assessment in Wallonia

Benjamin Dewals (ULg, abstract 6 and full paper) gave a presentation on flood risk analysis in Wallonia: a micro-scale approach. In his presentation an end-to-end flood risk analysis was performed including a hazard and vulnerability analysis to quantify damages (expressed in monetary terms). The hazard modelling is process-oriented and 2D hydrodynamic models are used. For the vulnerability assessment different data are used on micro- and meso-scale: cadastral information and detailed vector topographic maps for the micro-scale analysis and CORINE Land Cover for the meso-scale. Some examples were presented to show that a single risk number is not enough to communicate the idea of the concept. The whole damage curve (probability versus damages) has to be shown to see in which range of flood events a measure is beneficial and eventually where it is counterproductive.

Member States express flood risk in quantitative or in qualitative terms. MS having experience with CBA prefer expression in quantitative or monetary terms (Questionnaire results Q18). Risk in monetary terms provides a very useful metric to compare different management strategies and to prioritise measures, especially on a strategic level. Other MS prefer to express risk in qualitative terms on strategic level, due to lack of quantitative data, or because it is easier to communicate with the public. In many cases there will be a mixed approach. There is also a demand for evolution from qualitative assessments towards more quantitative assessments, when more data become available to do so.

The four types of consequences are also expressed in different ways by MS. Consequences on the economy are generally expressed in monetary terms. Only few MS do the same for human health, environment and cultural heritage. These consequences are more often expressed in quantitative or in qualitative terms. Many MS use a mixed approach, depending on subtypes of consequences and the availability of data to evaluate them.



4.2 Flood consequences and their classification

The consequences of flooding are multiple. The Floods Directive requires the assessment of four distinguished types (economic, social, environmental and cultural) without further definition or detail. In order to facilitate communication and thinking about the effects of flooding however further classification is necessary. Consequences are commonly categorised firstly in direct and indirect effects and secondly in tangible and intangible effects (Messner et al., 2007 and Penning-Rowsell et al., 2005b). See Table 1 for a non-exhaustive overview of flood consequences classified according to the typology discussed.

Direct effects cover all varieties of harm caused by the immediate physical contact of flood water to humans, property and the environment. Direct effects are usually measured as damage to stock values, representing a quantity existing at a specific point in time.

Indirect flood effects are effects caused by the consequences of the physical contact of flood water with damageable property.[9] This are the effects caused the disruption of physical and economic linkages of the economy. Indirect effects can be suffered both within and beyond the area of immediate direct physical flood impact. Indirect effects are often measured as a loss of flow values, measured over a an interval of time.

Tangible effects include all kind of damages that can easily be expressed in monetary terms.

Intangible effects cover impacts to those goods and services that are not traded in the market and, consequently, are far more difficult to assess in monetary terms than tangible effects.

[9] Messner et al. (2007) and Penning-Rowsell et al. (2005) also consider the extra costs of emergency and other actions taken to prevent flood damages and other losses as an indirect effect.

An additional dimension on the basis of which the consequences of flooding can be categorised is the division between primary and secondary effects. According to Parker (2000) **primary** effects are the 'first-round' or immediate effects. These immediate effects trigger further losses, which are termed **secondary** effects. The idea is that floods affect not just the property directly affected and the related indirect economic transactions, but that the impact spreads into the neighbouring economic units by a general disruption to the regional or sub-regional economy (Penning-Rowsell et al., 2005). Besides, flooding can also be classified as internal or external. UKELA (2010) stipulates **internal** flooding is used to designate flooding in a building, while **external** flooding points at the flooding in a garden or other open space such as roads or public grounds. Other definitions for internal and external flooding exist. Reyns et al. (2008) define those effects that lay inside the flooded area as internal. The effects outside the flooded area are designated as external.

Table 1 Overview of flood consequences

Direct		Indirect	
Tangible	Intangible	Tangible	Intangible
Damage to building fabric	Loss of life	Production and income losses	Increased vulnerability of people and companies
Damage to infrastructures	Physical and mental health effects	Clean-up costs	Disruption of community
Damage to crops	Loss of memorabilia and irreplaceable items	Costs of evacuation	Inconvenience caused by the disruption of utility services
Damage to inventories and consumer goods	Loss of ecosystem services	Increased travel costs	…

The drawback of the classification of flood consequences into direct, indirect, tangible and intangible losses is that it splits receptor groups. In the Halcrow (2008) report a different classification has been used that largely builds on the classification used in the Floods Directive: differentiating between impacts to social and economic receptors, cultural heritage and the environment. Based on this approach a catalogue of flood consequences is presented in Annex 4,**Error! Reference source not found.** in integrating the flood consequences identified in Halcrow (2008), Penning-Rowsell et al. (2005b) and Ecodecision (2006). The hierarchy of the flood consequences listed in the catalogue represents different levels of detail, and there is a sense in which level N impacts are an aggregate of level N+1. The different consequences listed at the same level interact. It, therefore, is not possible to simply sum all impacts.

The catalogue of flood consequences can be further extended with additional impacts and/or restructured according to the needs of the Member States. However Member States could develop a catalogue that is tailored to their specific needs and insights it would be good if Member States could agree on a common core set of flood consequences.

Examples of flood consequences considered in European countries can be found in Halcrow (2008) and Meyer et al. (2005).

It is relevant for a Member State to know what effects other Member States or regions assess or plan to assess. Knowing what other Member States do or plan to do can be helpful for Member States to define the scope of their own flood risk assessment efforts. The development of a catalogue that identifies what flood consequences are or will be commonly assessed by each Member States could facilitate decision making and priority setting in this respect by Member States that are still at the beginning of the process. The commitments of the more advanced Member States can serve as a sort of benchmark for the less advanced Member States. As the Member States explicitly state what effects they (will) commonly assess in the framework of the Floods Directive the Member States can converge to an informal consensus on the minimum requirements; what effects need to be considered for mapping the impacts to social and economic receptors, cultural heritage and the environment?

The catalogue of flood consequences commonly assessed could take the form of **Error! Reference source not found.**.[10]

The concept of ecosystem services of flood prone areas is relatively new (Millennium Ecosystem Assessment, 2005), and it is recommended to integrate aspects of the economics of ecosystems and biodiversity (TEEB - www.teebweb.org) into the flood risk assessments. Although floods have in most cases a negative impact on existing ecosystems due to pollutants or drowning of habitats, the fact that these areas are regularly flooded can protect them from development or in general from land use that is not compatible with flooding. The combination of flooding with compatible land use (nature, meadows,…) leads to a range of positive effects for the well-being of the society. As a conclusion the calculation of positive effects of flooding on ecosystems is in many cases not seen as appropriate (see also 4.3.2.3), on the contrary positive effects of ecosystem services on the society should be accounted for when flood areas are newly created or restored in the context of flood risk management measures as explained in part 5 of this document.

It is recommended, like it was also stated by participants in the Ghent workshop, to take the importance of the following aspects into account in risk analysis: external effects of floods, and the fact that systems (both statistical probabilities as well as assets at risk) do change over time. Collapse or failure of infrastructure and services should also be part of the scenario's. It is suggested to use the probability of the 'loss event' in addition to hydrologic probability. The prerequisite of this suggestion is that data of damages and other impacts is available for individual events, by calculating damages as explained in the next section and/or by exchanging damage pay-out information with insurers.

4.3 Methods for the assessment of the consequences of flooding[11]

The methods for the assessment of the consequences of flooding at least combine flood hazard and receptor location data, but very often also receptor vulnerability and

[10] As revealed by the answers on the F&E Questionnaire, MS take in many cases also indirect consequences of flooding into consideration, like production losses, cleaning costs or environmental impacts, sometimes through qualitative assessment. Consequences outside flooded areas are only rarely taken into account. Some MS also distinguish specific critical or sensitive values and resilience of risk receptors.

[11] Based on Halcrow (2008)

value data. In a first instance these generic building blocks of flood impact assessment methods are discussed. In a second time the methods for assessing the impact of flooding to social, economic, ecological and cultural receptors are discussed. These are the categories covered by the Floods Directive. The requirements of the Floods Directive are relatively limited with respect to the mapping of impacts as e.g. the valuation of impacts is not explicitly required by the Directive. The methods described may therefore go beyond the risk mapping requirements specified in the Floods Directive.

Participants of the Ghent workshop concluded that in addition to the requirements of the directive, additional overlays with calculated damages and other maps are necessary in the process of decision support, but these additional maps should not necessarily be shown to the public. Maps will have to be INSPIRE compliant. The information on data specifications for the implementation of the INSPIRE Directive can be found on the JRC website.

4.3.1 Scoping of the different types of flood impact assessment methods

The methods that are used for assessing the consequences of flooding vary considerably. Different types of flood consequences generally demand different assessment methods. There, however, are also a number of other reasons why assessment methods differ; data availability, knowledge, available resources (money, time, personnel), desired level of detail, flood characteristics to be considered, etc. Despite important differences the existing assessment methods all more or less start from the same basis; the different components of flood risk as presented in Figure 2.

Depending on data availability, knowledge, available resources (money, time, personnel), desired level of detail, flood characteristics to be considered the methods for assessing the likely impacts of flooding to a specific receptor vary from very basic (only counting the receptors-at-risk) to quite advanced (counting the absolute impact to the receptors-at-risk in monetary terms or another value scale), see **Error! Reference source not found.** for a schematic overview of the generic building blocks of flood impact assessment methods. Counting the receptors-at-risk is in its most simple form based on very basic hazard data (a map that only indicates the wet / dry flood state for a specific flood event) on the one hand and basic data on the location of the receptors on the other hand. Counting the absolute impact to the receptors-at-risk in monetary terms combines flood hazard data with receptor location, vulnerability and value data. The detail and quality of the input data may, however, also vary substantially. In between these two extremes there may exist a continuum of approaches. It is, however, noteworthy that the information that is derived on the basis of advanced flood impact assessment methods for a specific receptor is not necessarily more valuable to policy makers than information from more simple methods. The fact is that more advanced methods may provide a false idea of accuracy. The input data, relationships and assumptions used may be relatively more uncertain and undermine the value of the results. Because of lack of data, knowledge and/or the availability of appropriate models the extent to which various receptors are modelled varies greatly.

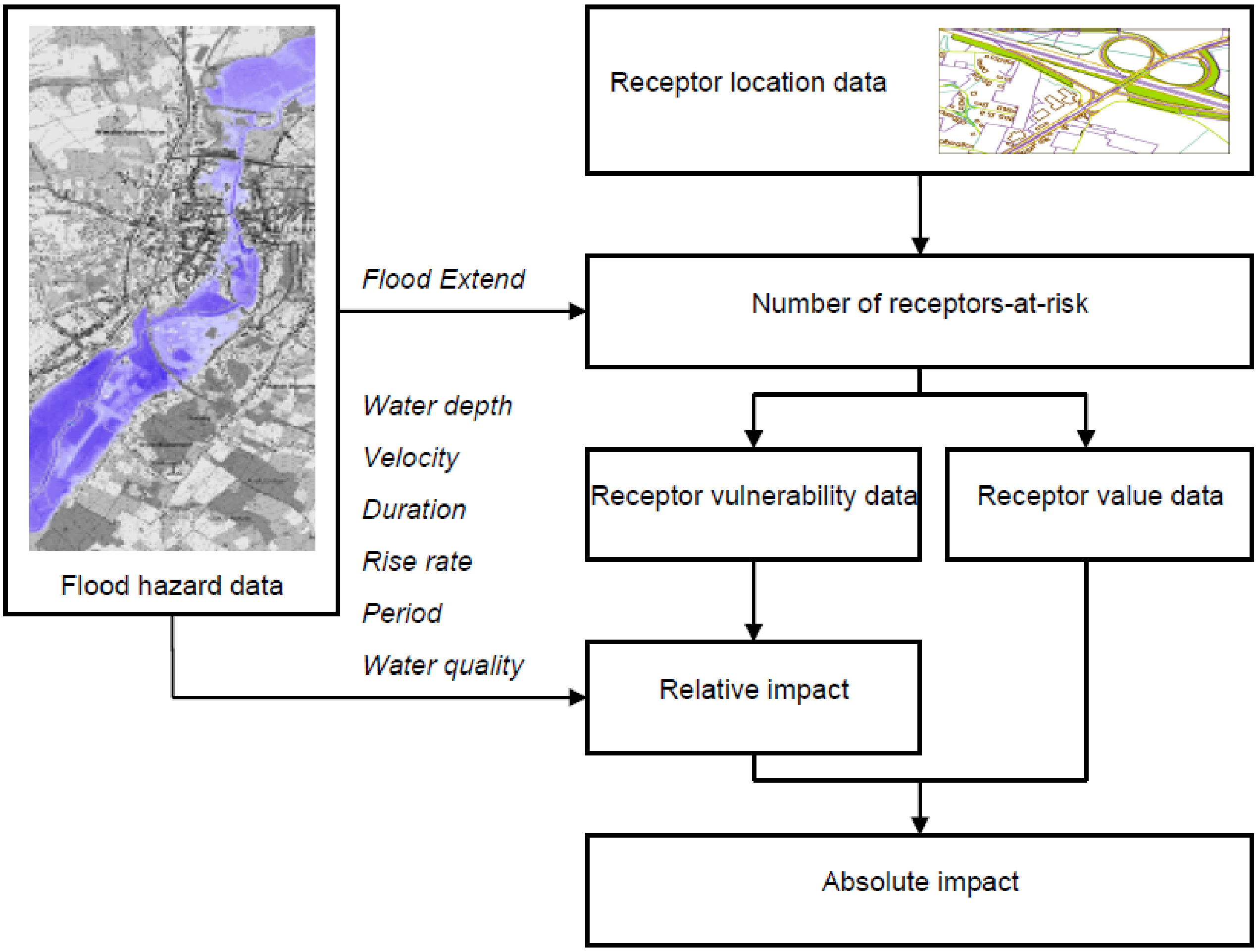


Figure 3. Generic building blocks of flood impact assessment methods

4.3.1.1 Flood hazard data

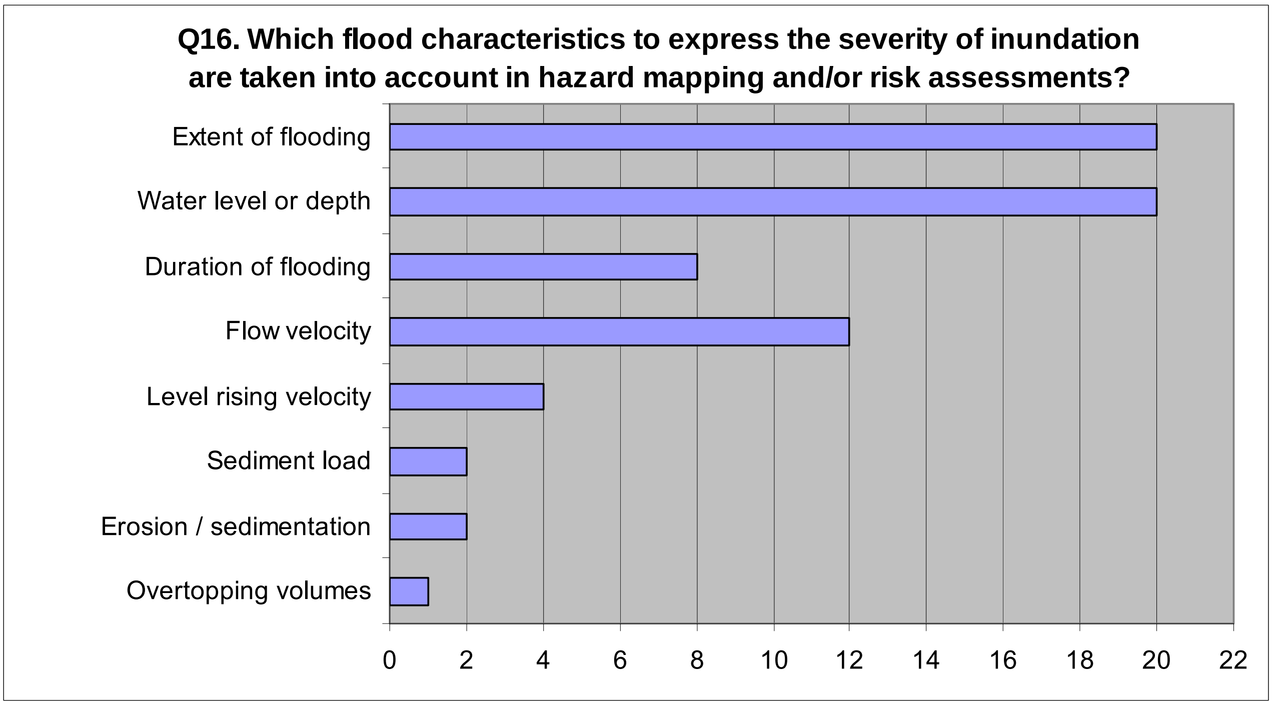
Flood hazard data can be either modelled by means of hydrologic and hydrodynamic modelling software, or based on observations. For calculating flood risk in such a way that it can be used in cost benefit analyses it is necessary to combine the consequences for a number of flood events with the expected occurrence, frequency, of these events. Depending on the purpose of an assessment the hazard data need to be mapped for different events of which the corresponding return periods are known. Good examples of flood hazard maps can be found in the EXCIMAP document. A flood hazard can be described in terms of flood depth, velocity, duration, rise rate, period of occurrence and water quality. Depending on the particular vulnerabilities of the receptors different flood characteristics become more important.

Information on the flood extent, indicating the wet / dry flood state for a specific event, is the simplest type of hazard data. Flood extent data are typically used to calculate numbers of people or properties affected by a flood. These indicators serve as proxies for risk to heath and economic damage.

Flood depth describes the depth of water at specific points in space. Flood depth depends on local water levels and topography. Flood depth is commonly simulated and used for the assessment of damage to property by means of depth-damage functions. It is also used for approximating the risk to people and ecosystems.

The flood characteristics velocity, duration, rise rate, period of occurrence and water quality are much harder to model. Data is often lacking. Consequently, uncertainty is higher for these parameters. Duration, period of occurrence and water quality are important for assessing impacts to ecosystems. Rise rate, velocity and water quality is important when considering risk to people. Velocity and duration may also impact on properties, infrastructures and related impacts. The salinity of flood water in coastal and estuarine areas may impact properties, ecosystems, groundwater and other systems as well.

All respondents (20) of the Floods&Economics questionnaire report the use of the flood extent and of the water level or flood depth to indicate the hazard of the flood events. Other indicators are less or even rarely used.



4.3.1.2 Receptor location data

Flood risk assessment and mapping requires overlaying flood hazard data (maps) with data on the location of the receptors considered. The data that can be used for this varies between regions and countries. A first step to determine flood impacts is to classify the elements at risk by pooling them into homogeneous classes. Flood damage assessments can show varying degrees of detail, depending on the spatial and temporal scale of the analysis. While micro-scale assessments usually consider very detailed and object-based information on houses, infrastructural elements or cars, meso- and macroscale assessments usually consider aggregated asset categories such as land-use units. Most often, classifications of elements at risk reflect economic sectors such as private households, agriculture, commerce or industry. As far as the residential sector is concerned, flood damage predominantly occurs at building structures and content and inundation depth and flow velocities have been identified as an important damage-influencing parameter. In contrast, agricultural areas are predominantly affected by a loss of crops. Here, the season when the flood occurs and the duration of the flood are the decisive damage-influencing parameters. Another advantage of classifying elements at risk along economic sectors is the fact that economic data, which are needed for damage assessments, are often readily available on aggregated levels from national or regional statistical offices (Bubeck and Kreibich, 2011).

As receptor location data is crucial for assessing flood impacts it greatly influences the selection of the most suited flood impact assessment methods.

Georeferenced cadastral data with the description of the function of each property could proof very useful. The same is true for land use maps like Corine land cover. Georeferenced cadastral information and Corine land cover data, however, differ very much in terms of thematic accuracy and precision.

Specific receptor data like critical line infrastructure or point infrastructure, cultural heritage etc. can be extracted from different thematic data layers depending on national or regional databases.

Population data can be taken from population censuses. For small scale and/or very detailed assessments or simply when too little data is available it may be necessary to gather data on the basis of surveys. Data collection on population falls within the legal requirements and limitations as set out by the EU Data Protection Directive 95/46/EC.

4.3.1.3 Receptor vulnerability data

There exist two approaches on the basis of which vulnerability of receptors is characterised. The first type consists of the so-called depth-damage functions, which may be extended to incorporate other flood characteristics as well. The second type is an index based approach.

A damage function describes the susceptibility (and thus also the vulnerability) of a receptor against specific flood characteristics. There exist two kinds of damage functions: relative and absolute damage functions. A relative damage function specifies what percentage of the total value of a receptor is lost/damaged in function of the level of one or more flood characteristics (mostly depth) to which it may be exposed. An absolute damage function integrates receptor vulnerability and value data, it is a combination of a receptors value and a relative damage function. Currently, damage functions are mostly used for assessing the susceptibility of tangible items.

Some damage functions exist that also take vulnerability (resistance) parameters into account, such as differences in building structures or the level of undertaken mitigation measures (e.g. BUWAL, 1999a; Keiler et al., 2006, BAFU, 2010).

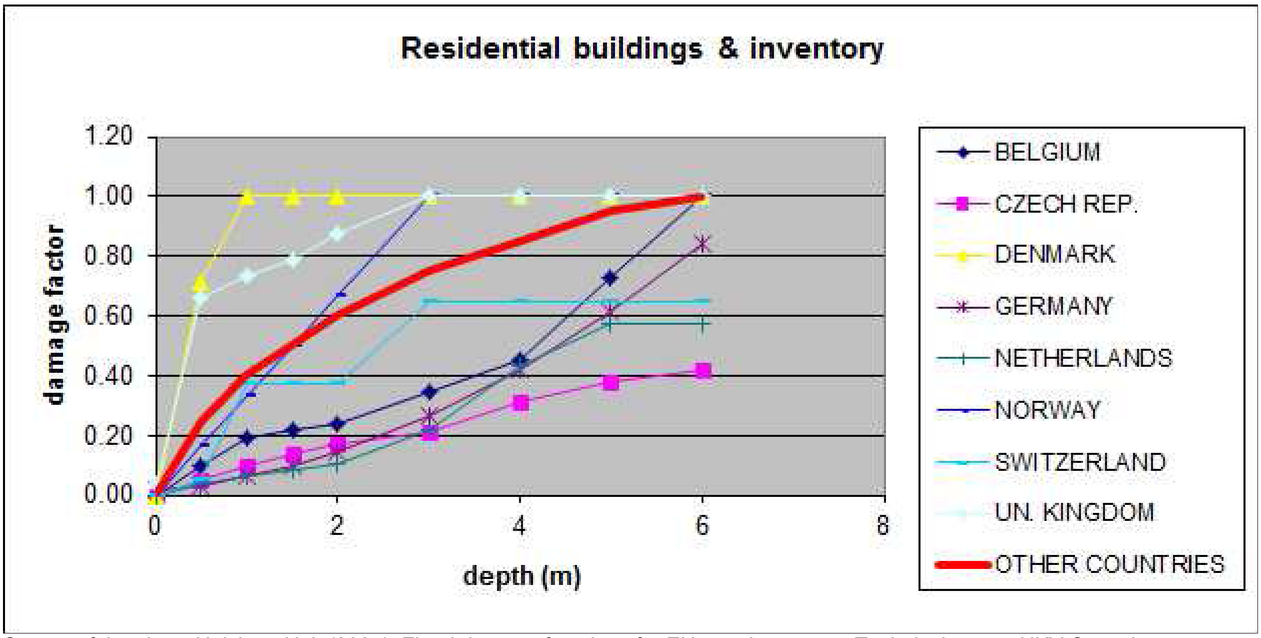
Index based approaches determine a receptors' vulnerability on the basis of a number of its characteristics. For each characteristic an indicator is developed for which one or more threshold levels are defined. The scores for the different indicators are aggregated into an index. A well-known example is the Social Flood Vulnerability Index developed by Tapsell et al. (2002).

There are mainly two approaches to develop damage functions that are needed for flood risk assessment (Bubeck and Kreibich, 2011). First, damage functions can be empirically derived using observed flood damage data. An example for such an empirical data base is the HOWAS data base and its successor, the HOWAS 21 data base in Germany, which currently comprises almost 6000 individual damage cases from different economic sectors, such as private households, industries and infrastructures. This database was e.g. used to derive the FLEMO, MURL and Hydrotec damage functions. Second, damage functions can be derived using a synthetic approach. Following this approach, experts e.g. from the insurance industry or engineers estimate the amount of damages that would occur at a specific element at risk under certain flood conditions. The Multi-coloured Manual in the UK, the HISS-SSM in the Netherlands or LATIS, which is the standard software in Flanders (BE) to evaluate flood damages, are examples of this approach. Both approaches can also be combined, as it was done in the case of the so-called Rhine Atlas provided by the International Commission for the protection of the Rhine or in Australia. Both approaches have advantages and disadvantages. Besides, a choice needs to be made between relative and absolute damage functions. While relative damage functions define the expected damage as a proportion of the maximum asset value, absolute damage functions estimate the expected damages directly in monetary terms. Relative damage functions are e.g. applied for damage assessments along the river Rhine. In the UK or in Australia, absolute damage functions are used.

Several studies have outlined the large uncertainties associated with flood damage assessments. The uncertainties stem from the fact that very complex damaging processes are usually described using simple depth-damage functions. An example of a multiparameter flood damage model that takes several damage influencing parameters into account is the FLEMOps series. Validations of the original model and its enhancements showed that such multi-parameter models outperform standard flood damage models that only relate damage to water depth (Kreibich et al., 2011).

JRC has been working in a 2007 project on a database with flood damage functions intended for EU Member States to help them to calculate flood damage potential. These functions relate water depth and economic damage for the assessment of direct damages caused by floods. The flood damage functions are averaged from functions that are used in 11 countries, and they are adapted to be used together with Corine land cover datasets. More information can be found in the Ghent workshop presentation by José Barredo or on http://flood.jrc.ec.europa.eu . The JRC flood damage functions are of special interest for general scoping purposes or for Member States where detailed flood risk information is not yet available.

The uncertainty of damage functions is reflected by significantly different shapes of damage curves that are applied to estimate direct flood damage to residential buildings in Europe.



Source of the chart: Huizinga H.J. (2007): Flood damage functions for EU member states. Technical report, HKV Consultants. Implemented in the framework of the JRC contract #382441 F1SC.

4.3.1.4 The estimation of losses caused by the disruption of production processes

Losses due to the disruption of production processes occur in industry, commerce or agriculture in areas that are directly affected by a flood event, for example when people are unable to carry out their work due to a destruction of their workplace or because it cannot be reached. Losses due to the interruption of production processes that occur outside of the flood area, e.g., because suppliers are no longer able to deliver their products, are defined as indirect damages in the CONHAZ project and thus not addressed in the present report.

The US model Hazus-MH MR5, which is provided by the US Federal Emergency Management Agency (FEMA, 2011), estimates losses due to the disruption of production processes on the basis of relocation expenses, capital related income losses, wage losses and rental income losses. Relocation expenses include the cost of shifting and transferring, and the rental of temporary space. These costs are assumed to be incurred once the building reaches a damage threshold of 10%. Cost per day and area factors are specified for various economic sectors in order to derive monetary losses. Capital related income losses, wage losses and rental income losses are estimated depending on the building recovery time. Building recovery time is calculated by summing up the time needed for physical restoration of the building, as well as time for clean-up, time required for inspections, permits and the approval process, as well as delays due to contractor availability. All these components are estimated in dependency of water depth and business branch. The thus derived flood and sector specific building recovery time is used to estimate monetary costs per day and area, which are defined for various economic sectors (e.g. wage per square foot per day for the financial sector).

4.3.1.5 Receptor value data

The value of a receptor is used to translated the degree to which a receptor is impacted into the corresponding loss or damage to society. In its most straightforward form the receptor value is expressed in monetary terms. An alternative could be a sort of (semi) quantitative or qualitative scale. Such a scale is used when monetisation is either not possible or desirable. It is advisable to develop a scale that represents something meaningful to those that need to work with it. Policy makers need to understand what a certain score represents as it will have to be compared to the losses to various other receptors, expressed in different scales.

Assessing the monetary value of a receptor or the change in the value of a receptor can be done in different ways, depending on the receptors' characteristics. The available methods can be divided into three broad categories: revealed preference approaches, stated preference approaches and benefits transfer.

	Methods	Description
Revealed Preference Methods	Hedonic pricing methods	Used to estimate the impact of environment on market values such as houses considering that the value of assets is function of some characteristics including the environment.
	Travel Costs method	Used to estimate use value associated with ecosystems or sites based on time and travel costs spend by people
	Cost of Illness Approach	Used the medical costs or wages/income lost as an estimate of health impact
	Replacement Cost Method	Use to estimate the services of the environment by considering the costs of technologic substitute
	Production Function Approach	Use to estimate the production value of the environment by considering its contribution in production of market product
Stated preferences Approach	Contingent Valuation Method	Questionnaires directly addressed to individuals assessing their willingness to pay (WTP) or to accept (WTA)
	The Choice Modelling Method	Individual have to chose between different alternatives scenarios based on an array of attributes
	The Life Satisfaction Method	Individuals have to evaluate well -being, life satisfaction or happiness rather than economic value. The economic value is then assessed based on their answer and their socio-economic indicators (utility function)
Benefit Transfer Method		Consist in transferring the results of pre-existing studies (Stated or revealed) based on statistical similarity with the case study

(from Green et al. 2011)

The common feature of revealed preference approaches is that they are based on observed economic behaviour, from which individual preferences can be derived. For a priced good sold in a perfectly competitive market the prevailing price equals the value of that good or receptor. In the real world markets are commonly distorted and hence prices will need to be corrected. Other receptors may not be traded in markets, but there may exist a relationship between goods traded for in the market and the receptors studied. The value of these receptors can then be derived by using statistical techniques. The travel cost method, hedonic pricing method, replacement cost method and production function method may be used for valuing receptors or the changes in the quality and/or quantity of a receptor by establishing a link to goods that are effectively traded in markets.

Only in a perfectly competitive market does a price equal the economic cost and also the economic value of the good or service. Many receptors are not traded in markets and are not closely related to any marketed goods. Consequently, people's willingness to pay is not revealed through their economic behaviour. In these cases stated preference approaches can be used to directly measure people's willingness to pay by means of surveys. These methods establish a hypothetical market in order to elicit respondent's willingness to pay for a receptor or the changes in the quality and/or quantity of a receptor. The most known and applied stated preference method is contingent valuation, an alternative stated preference valuation technique is choice modelling.

Another area where there are problems is in estimating the second and subsequent order impacts. For example, it is much more difficult to estimate the losses that result from a factory being out of production for some period of time than the damage to the factory itself. The scale of analysis is important: the local effect will differ from the effect on the national economy. The difficulties of evaluating such impacts arise largely because the assumptions of perfectly competitive markets and equilibrium conditions are not met in practice (Green et al. 2011).

Carrying out original valuation studies is often expensive and time consuming. However, if a similar effect to a receptor has already been valued elsewhere, this estimate may be transferred in time and space and serve as an indication of the economic welfare people attach to a certain receptor or to the changes in the quality and/or quantity of a receptor. Benefits or value transfer is defined as the transposition of monetary values from one site through market-based or non-market-based economic valuation techniques to another site. The 'recycling' of results of original valuation studies is not without problems. Care should be taken to keep the uncertainties within acceptable limits. (Brouwer, 1999)

Economic loss (nation, public point of view) has to be distinguished from financial loss (private point of view) as they are not accounting for the same value. Financial losses will integrate all types of losses at current price including taxes. When valuing economic losses the taxes have to be excluded, any losses compensated by a gain should not be counted and only the depreciated value should be considered (Penning-Rowsell et al., 2003).

The Stirling workshop revealed the need for better tools to measure the value of different types of land use (including agriculture) within the context of flood and environmental management.

4.3.2 Developing a catalogue of methods for the assessment of the consequences of flooding

From a stakeholder's point of view loss damages assessment methods are available to answer the first requirements of the Floods Directive. Issues mainly remain in terms of data availability and data quality (Green et al., 2011).

Below the methods for assessing the impact of flooding to social, economic, ecological and cultural receptors are scoped/introduced and discussed in a general manner, making reference to a number of specific examples. For many receptors there exist a number of alternative methods that vary from the methods referred to in the text in terms of the flood hazard data and/or the receptor location, value or vulnerability data used. The differences between the different methods for assessing the consequence of flooding to a specific receptor result from differences in data availability, knowledge, available resources (money, time, personnel), desired level of detail, type of etc. at the Member State or regional level. Methods may e.g. be macro, meso or micro scale, e.g. depending on the data(bases) used for describing receptor location data, and assess the consequences of flooding in monetary terms, quantitatively or qualitatively.

With regard to the implementation of the Floods Directive Member States are interested in getting to know the methods used in other Member States and regions in order to be able to define how they will do it themselves. In order to present the available practices for the assessment of the consequences of flooding to a specific receptor to the Member States a catalogue of methods for the assessment of the consequences of flooding will be developed. It is proposed to introduce/describe each selected (good practice) method for the assessment of the consequences of flooding to a specific receptor in terms of a number of characteristics, using a standardized fact sheet like the one presented in **Error! Reference source not found.** Annex 5, illustrated with examples of France. Parameters that could be covered in these fact sheets are a description of the required input data (with regard to the hazard, the location of the receptor, vulnerability characteristics of the receptor and the value of the receptor), a description of the method, a description of the output derived (in terms of the scale, the level of detail, accuracy, etc.), information on the validation of the method, references to more detailed information on the method (e.g. possibly brought together on Circa or another platform), a discussion on advantages, drawbacks, potential problems, etc. as well as specific recommendations for application elsewhere.

Besides the examples explained by Meyer et al. (2005), recent examples of methodologies for vulnerability and risk assessment can be found in the Floodsite reports or were reported in the answers to the Floods&Economics questionnaire, which can be found in Annex 3.

Next to a catalogue of methods it may also be valuable to draft an inventory of interesting database initiatives: Member States may have developed specific receptor location database, a database of depth damage data from past floods, a database of receptor values, etc. Such initiatives may be worth sharing with the other Member States. Assigning monetized, quantitative and/or qualitative values to the specific receptors is a common problem to all Member States. Exchanging good practices of how to proceed with this or even developing a catalogue of values may therefore be useful, especially when it concerns non-use values. However the values of specific receptors may vary between countries it may be possible to transfer values from one location to another.[12]

4.3.2.1 Social impacts

The Floods Directive requires to assess the impact on human health; the mapping requirements include the “indicative number of inhabitants potentially affected” for the flood scenarios referred to in Article 6 (3) of the Floods Directive. The indicative number of inhabitants potentially affected can be regarded as a proxy for the immediate risk of death and serious injury which requires much more data as well as modeling capacity and effort. The indicative number of inhabitants that are deemed to be affected can be further refined in order to account for the vulnerability to flooding of the people affected by means of a sort of social flood vulnerability index. Another approach for quantifying and/or mapping social impacts consists of counting the social infrastructure sites or sites with vulnerable people.

Indirect and intangible social effects of flooding like e.g. all kinds of immediate and long term physical (injuries, headaches, infections, cardiac problems, gastro-intestinal illnesses, etc.) and psychological (anxiety, increased stress levels, depression, sleeping problems, mood swings, etc.) health effects are believed to be important. Coninx et al. (2009a) define social impacts as impacts that can be experienced physically or mentally by humans at different levels (individual, family or community), which are induced by changes in the physical, economic, cultural, ecological or social system and which alter the way people live, work, relate to one another or organise to meet their needs and generally cope as members of society. Recent research aimed at understanding the social effects of floods has revealed that these impacts are sometimes rated as worse by those affected than the economic and financial losses suffered. Much effort is still needed to make progress in quantifying these types of effects. (Penning-Rowsell et al., 2005b and Halcrow, 2008)

Most social flood risk assessment methods or indicators take the number of people exposed as the starting point. Often the number of people exposed is approximated

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[12] The presentation by Edmund Penning-Rowsell (FHRC Middlesex) in the Ghent workshop showed the experience of Forty years of flood damage research at Middlesex University**.** Some theoretical frameworks were presented with illustrations to make the concept visible. Methods changed over time, not only due to new research insights but also because ‘the real world’ is changing, so new inventories for damage have to be made, changing the depth-damage curves as well. Lots of attention was given to health effects of flooding and emergency costs. Several times the dynamics of flood damage calculations over time was shown.

Other valuable input for Member States was presented by José Barredo (JRC): Flood damage functions for EU member states - “Flood risk mapping using Corine land cover datasets”. This presentation gave an overview of the work done on a EU wide scale. The idea is to set up a flood damage functions database for EU countries based on Corine Land Cover and with water depth as the only hazard parameter. The idea is to provide this information to MS who don’t have this information available for the moment, not to replace the existing national and regional systems (often with much more detail). Also for (international) catchment wide studies these data can be beneficiary.

Reimund Schwarze (UFZ, abstract 16) presented the ConHaz (Cost of natural Hazards) project. Based on the vision of ConHaz possible evolutions of economic welfare in potentially flooded areas were explained. More information on the ConHaz project can be found on www.conhaz.com .

using data on the number of people living in the flood risk area. The assessment of this number is complicated by the fact that people are mobile. There may be important differences between day/night and weekdays/weekends. How to treat second homes? What if people's workplace is flooded? What about the social impact to people who are not flooded themselves, but have relatives or friends that are flooded? The assessment of the social impact to people is always an approximation.

Ghent workshop participants recommended not to limit social impacts to number of people affected or number of victims, also loss of social services should be taken into account. It is also recommended to communicate with stakeholders with maps showing critical social infrastructure and effects on transport and other networks and utilities.

It was questioned how impact on mental health could be taken into account. Another observation was that there are different interpretations of the value of a statistical life between insurers and other policy fields, and different views on how to take into account fatalities. In some MS fatalities are not accounted for in CBA because any life is considered to have equal importance regardless of the number of inhabitants. In other MS the number of potential fatalities is extremely important and has a high influence in the outcome of economic assessments. Some MS have objections against monetising human lives.

An alternative would be to analyse the number of potential victims, and to use it as a criterion in a MCA or so-called extended CBA, which is best suited to combine monetary and non-monetary impacts. Yet another alternative is the use of CEA (with examples in road safety and air quality), where the marginal value of investment is a measure for human lives. The problem with such an approach is that floods consist of frequent events with a limited impact and rare extreme events with a large impact.

See also OECD meta-analysis in different countries and UNISDR guidelines.

4.3.2.1.1 Indicative number of inhabitants potentially affected and hazard to life

This is a useful proxy for social and health impacts, and does not require velocity or depth

information. Population statistics or census data can be used to calculate the population living in the inundated area. This is mostly done by multiplying an average occupancy appropriate to the country, region or community in question with the residential properties located in the flood area. The receptor location data ideally consists of georeferenced cadastral data that provides a description of the function of each property. When such georeferenced data is not available it may be possible to identify residential areas on land use maps and an average housing density to these areas located in the flood area.

There currently exist methods for assessing the expected risk to death and serious injury (Waarts, 1992; Vrouwenvelder et al.,1997; Jonkman 2001, 2004 en 2007; HR Wallingford 2005; Priest et al., 2007; Zhai et al., 2006 and DEFRA, 2008). The existing models are, however, still very much open for improvement.

To date the expected number of casualties is estimated on the basis of inundation depth, velocities and rise rates for low-lying areas. Efforts are also under taken to model the effect of flood warnings and the presence of escape routes (Jonkman, 2007 and Parker et al., 2008). Methods have often been developed for a specific type of inundation and region. In the framework of the European Floodsite project Priest et al. (2007) attempted to estimate risk to life for European flood events.

Existing methods are only validated to a limited extent on the basis of empirical data. This is because very little is known about the likely loss of life in floods as well as the various causes. River flooding differs from coastal flooding. Flooding in a river delta with typical low-laying polders is a specific situation. The causes underlying a flood may also vary much (storm, extreme rainfall, sudden melting of snow, failure of dikes, etc.).

4.3.2.1.2 Social infrastructure and high vulnerability sites

In England and Wales social infrastructure (e.g. schools and hospitals) and high vulnerability sites within the flood risk area (e.g. residential homes of children and elderly) are mapped and counted on a basin scale. These counts and maps help to identify social hot spots-at-risk. The availability of location data of schools, hospitals, elderly homes, etc is crucial. (Halcrow, 2008)

4.3.2.1.3 Social Vulnerability Indexes

Communities that are more vulnerable will be hit harder than others given the same exposure to a given hazard. Insight in the vulnerability of communities is important for policy and decision makers as this could alter their investment priorities in order to better protect the most vulnerable people. Identifying areas with high flood vulnerability may guide the decision making process towards a better way of dealing with floods by societies.

The Social Flood Vulnerability Index is used in the UK to both identify and quantify people's vulnerability to flooding. Coninx et al. (2009a, b and c) have developed a social flood impact index for Belgium, comprising a social flood vulnerability index which combines household susceptibility and communities' resilience / adaptive capacity to flooding. The social flood impact index provides a standardised, comparable in time and space, score for each person living in the area-at-risk.

4.3.2.2 Economic impacts

The Floods Directive requires to evaluate economic impacts; the mapping requirements include the "type of economic activity of the area potentially affected" for the flood scenarios referred to in Article 6 (3) of the Floods Directive. The types of economic activity that are generally considered when assessing flood impacts are both residential and non-residential properties, infrastructures like utilities and transport, agriculture and recreation.

The most simple approach for assessing the potential impact from flooding consists of counting the number of properties exposed per receptor type. Multiplying the number of receptors exposed by their corresponding value provides an indication of the maximal direct damage. Instead of assessing the total value of the economic receptors-at-risk depth-damage functions are used to determine the extent to which each economic receptor is affected.

The damage functions used by economic flood impact assessment projects are either specifically developed to meet regional characteristics or borrowed from other flood impact assessment initiatives elsewhere. Damage functions can be developed in two ways. First, by running a regression analysis on the basis of an extended dataset with information on the receptors considered. Second, by a bottom-up analysis conducted by engineers on the basis of their technical expertise.

4.3.2.2.1 Residential and non-residential properties

4.3.2.2.1.1 Housing and household goods

Residential properties are probably the type of receptor that is assessed most often in economic flood impact assessment projects.[13]

Houses are frequently traded in the market. Market prices of houses include land prices, which may increase without influencing potential damage, so for determining the value of a house land prices shall not be taken into account. In most European countries there is sufficient data available on house values. The value of household goods is often assumed as a percentage of the total house value. This factor can be estimated on the basis of information from the insurance sector or from public statistical data. Care should be taken when using information from the insurance sector revealing financial impact instead of economic impact. To evaluate the economic impact depreciated values should be used instead of full replacement values. Assuming a linear depreciation the average depreciated value (also called net value) of a set of assets would be 50% of the new value (also called gross value).

4.3.2.2.1.2 Industry and inventories

The methods for the ex-ante damage assessment to industry are clearly less accurate than those for calculating the damage to e.g. residential properties. The sector industry is complex and diverse. The number of industrial properties that have been damaged from flooding is far more limited than for residential properties. This makes there is relatively few information for making sound damage functions. (Vanneuville et al., 2006 and Reyns et al., 2008)

Het FHRC developed damage functions for different categories of economic activities, each subdivided in a number of sub categories like e.g. warehouses (distribution and logistics) and workshops (manufacturing), differentiating between 'building structure and fabric', 'building services', 'movable equipment', 'fixtures and fittings' and 'stocks'. For each function there exists a version with a low, indicate and high ssusceptibility band on the basis of which uncertainty can be (Penning-Rowsell et al., 2005b)

The researchers of the GeoForschungsZentrum Potsdam developed the FLEMOcs-model for the ex-ante calculation off the damage to industry, differentiating between various economic sectors (Kreibich et al., 2009).

Reyns et al. (2008) discern sixteen different industrial activities. These categories have been attributed damage functions that were taken over from Prenning-Rowsell et al. (2005).

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[13] The most well-known set of (absolute) damage functions is composed by the Flood Hazard Research Centre (FHRC) and can be found in Penning-Rowsell et al. (2005b). These damage functions are generally used in Ireland and the United Kingdom. In Germany (Thieken et al., 2009b; ICPR, 2001 and MURL, 2000), the Netherlands (Kok et al. 2002 and 2004 and Vrisou van Eck et al. 1999a and 1999b), Belgium (Vanneuville et al., 2006 , De Rouck et al., 2004 and Deckers et al., 2009) and France (Torterotot, 1993 and CEPRI, 2008) relative damage functions are used, although in France the ministry mostly uses absolute damage functions. Damages to household goods are assessed on the basis of a specific damage function (Penning-Rowsell et al., 2005b; Vanneuville et al., 2006; Kok et al. 2004; Torterotot, 1993; ICPR, 2001 and MURL, 2000). The loss to the movable household items can, however, be reduced given timely and effective flood warnings are provided to the population (Parker et al., 2008).

The methods developed by Kok et al. (2004) and ICBR (2001) do only have one damage function that is used for different industries. The method developed by MURL (2001) has a specific damage function for companies active in the mining of minerals.

Attaching a value to an industrial company is not easy. The tangible assets of a company are hit first. The value of these assets can be read from the balance sheet, but these figures may differ quite a bit from their real value. The impact of a flood, however, may go well beyond the loss of assets as the value of a company depends very much on its future profits. If valuing the loss to industry is necessary and there are no resources for a detailed assessment one could derive an average value per m² or employee for companies active in a specific sector.

Flooding may also impact on supplier or client companies that are not flooded themselves. Penning-Rowsell et al. (2005b) state that, from the point of view of the economy as a whole, the indirect damage from the disruption of a company's activities is quasi only relevant for very specialised production facilities and/or stocks are low. Temporary interruptions from non-specialised production facilities are not critical to the economy as other companies are able to increase their activity. As a general rule indirect effects tend to be more important in case long duration floods and events affecting a significant proportion of a region or country. (Messner et al., 2007)

4.3.2.2.1.3 Other properties

Besides residential and industrial properties there exists an important, but heterogeneous group of properties. With the exception of the (absolute) damage functions developed at the FHRC there are quasi no specific damage functions for all sorts of shops, the hotel and catering business, offices, sports and leisure facilities and public buildings of all kind. (Penning-Rowsell et al., 2005b)

Attaching a value to these kind of properties if often very difficult unless there is . The flood impact assessment methods may therefore limit themselves to counting the number of properties in flood risk area.

4.3.2.2.2 Public utilities and related infrastructure

When floods impact on public utilities like electricity and gas supply, water distribution, sewerage systems, sewage treatment and telecommunication this may have far-reaching consequences. Entire areas may be left without basic services when nodal points are affected; causing important indirect effects. The most common way of assessing the possible disruption of these services is by identifying and counting the most vulnerable points or installations of these systems in the potential flood area. The identification of these installations can be done on the basis of georeferenced spatial property databases, information from infrastructure management bodies, local knowledge or surveys. (Halcrow, 2008, Messner et al., 2007 and Penning-Rowsell et al., 2005b)

4.3.2.2.3 Roads and railways

The impact to roads and railways is often accounted for by counting the length of rail and road that is flooded, sometimes distinguishing different classes. Vanneuville et al. (2006) en Kok et al. (2004) do provide a method to assess the direct damage to transport infrastructure. When roads or railways are blocked traffic is disrupted and people lose time. Penning-Rowsell et al. (2005b) discuss the impacts of road and rail traffic disruption which is mostly function of the number of people affected.

4.3.2.2.4 Agriculture

Penning-Rowsell et al. (2005b), De Nocker et al. (2007) and Deckers et al. (2008) provide methods and receptor value and vulnerability data for monetising the impacts floods have on agricultural production. The degree to which agriculture production is impacted depends very much on flood characteristics like the period of occurrence (winter, spring, summer, autumn), duration, depth and quality and salinity of the flood water. The cultures covered by these methods are extensive and intensive grass land, maize, cereals, potatoes, sugar beets, vegetables and fruits. Carrying out such an assessment requires detailed data on the cultures grown on each parcel. A more pragmatic approach consists in using statistics on the share of each culture in the total agricultural area at the local level. Penning-Rowsell et al. (2005b) provide tools for assessing the benefits of better drainage of agricultural land.

The easiest way of accounting for agricultural losses consists of counting the surface of the agricultural land covered by floods.

4.3.2.2.5 Recreational enjoyment

How to assess the impacts on recreational enjoyment as a result of flooding is described in Penning-Rowesell et al. (2005b). Recreational enjoyment is defined as the enjoyment of landscape, wildlife and natural amenities as well as recreational activities. The method comes down to assessing the impact varying flooding conditions (with or without a specific flood risk management scheme in place) of a site has on recreational enjoyment on the one hand and the number and type of users / visitors of the site. How the users of a specific site value the impact of different flooding regimes on their recreation enjoyment of a site can be assessed using revealed or stated preference methods or benefits transfer. An alternative to valuing the impact on recreational enjoyment can consists of a simple count of the number of visitors of sites affected by flooding.

4.3.2.3 Environment

The Floods Directive requires to assess impact on environment; the mapping requirements include the “installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC) which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;” for the flood scenarios referred to in Article 6 (3) of the Floods Directive.

Impacts on the natural environment have been quantified using a measurement of area likely to be affected by flooding. The impact of flooding on water quality has been assessed both in terms of potential pollution sources, such as contaminated land sites and industrial activities referred to in Annex I to the IPPC Directive.

Changing flood regimes and polluted flood water may affect ecosystems and the services they provide. Runhaar et al. (2004) and De Nocker et al. (2007) present methods for quantifying the compatibility of flooding and ecosystems. Based on a biological valuation map it is possible to quantify the impact of varying flooding conditions (with or without a specific flood risk management scheme in place). Penning-Rowsell et al. (2005b) discuss whether it is useful to evaluate impacts to environment and ecosystems in economic and monetary terms. Turner et al. (2005) present different methods and techniques for valuing the impacts to multi-functional wetlands using the ecosystem approach. Liekens et al. (2010) have developed a manual for monetising the impact of infrastructure projects on site specific ecological values. The manual contains both factors and functions for monetising the effect to specific ecosystem goods and services provided by the site.[14]

Today the total economic value (TEV) framework and the ecosystem approach are most commonly used for valuing the impacts of flooding on ecosystems. The starting point of the ecosystem approach is that well-functioning ecosystems are essential for our continued existence as we derive goods (such as food and timber) from them and they perform fundamental life-support services (like maintenance of air and water quality, detoxification and decomposition of wastes, maintenance of soil fertility). Besides, humans also enjoy ecosystem services that go beyond the provision of basic life support services, such as recreational and aesthetic values. Furthermore, natural ecosystems also have an intrinsic value. The TEV framework is used to account for the multiple values people hold for ecosystems. It helps to identify and categorize the different ecosystems benefits, going beyond the direct use values. (Daily et al., 1997; Farber et al., 2002; Emerton et al., 2004; NRC, 2004 and Millennium Ecosystem Assessment, 2005)

The assessment of the costs of changes in services provided by ecosystems requires the explicit integration of ecology and economics. The input of ecology is required to assess how ecosystem structure and processes and the resulting ecosystem functions change under different conditions. Both ecology and economics are needed to comprehend how the effects on ecosystem functions translate into the production of ecosystem services. Finally, the input of economics is required to assess how the change in ecosystem services impacts on human welfare. (NRC, 2005; USEPA, 2006 and Farber et al., 2006)

The assessment of the ecological costs of environmental degradation is complicated by several factors. Despite significant advances in the understanding of ecosystem services and the natural processes that underlie them, the knowledge of these complex systems remains incomplete. As a result, some ecosystem services may simply be not recognised. The same goes for the actual estimation of the benefits of the proposed policies to human welfare. The valuation exercise is complicated because on the one hand the effects on ecosystem services cannot always be clearly described and quantified and on the other hand, the data and methods for the actual valuation are often limited. (USEPA, 2006)

To date important work with regard to the evaluation of the value of ecosystem services is being undertaken in the framework of The Economics of Ecosystems and Biodiversity (TEEB) initiative. The aim of the work on TEEB is to evaluate the costs of the loss of biodiversity and the associated decline in ecosystem services worldwide, and comparing them with the costs of effective conservation and sustainable use. It is intended that it will sharpen awareness of the value of biodiversity and ecosystem services and facilitate the development of cost effective policy responses and better informed decisions. To this end the TEEB initiative wants to create a robust methodological framework that enables the decision-makers at different levels to do economic analysis of ecosystem services and biodiversity.[15]

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[14] The factors and functions have been developed for the Flemish region (Belgium) and are based on both a new valuation study carried out for this purpose as well as a host of other valuation studies.

[15] For more information on TEEB see http://www.teebweb.org.

The contribution of Pierre Strosser (Acteon Environment) related to the Ghent workshop "Linking ecosystems goods and services and the Floods Directive: Food for thoughts" gave more insight in the contribution of ecosystem services in flood risk assessments.

As revealed in the Ghent workshop, most MS consider risk of potential contaminated flood waters, potential pollutants and link to WFD objectives as being most important for environmental consequences. Ecological impacts of flooding are not yet taken into account by most MS, environmental impact is often seen in relation to contaminated water. This is a relevant issue for the interpretation of Art. 6 §5 c).

4.3.2.4 Cultural heritage

Cultural heritage located in the flood plain is typically counted from either local knowledge or spatial property data (Halcrow, 2008). The value and susceptibility of cultural heritage is very case specific. Valuing the impacts to this type of assets would require substantial effort.

In the Ghent workshop it was explained that some MS estimate cultural heritage with a higher vulnerability (intangible effects) in order to get a higher protection level. Others indicate that cultural heritage already in place for hundreds of years may not significantly be affected by flooding.

4.4 Calculating flood risks

The method for calculating flood risks is relatively uncontroversial. It comes down to combining the consequences for a number of flood events with the expected occurrence, frequency, of these events (Penning-Rowsell et al., 2005b). Not all Member States currently translate the impacts from different events into an estimate of flood risk nor would the approaches of the countries that do calculate flood risk be all similar.

Example of calculating economic risk

Error! Reference source not found. (Vanneuville et al., 2002) describes the procedure for calculating the expected yearly average flood risk, using the consequences associated to the full domain of probabilities derived by interpolating the consequences associated to a limited number of flood events, as it is currently done in Flanders. In a next step the yearly average flood risk can be discounted for the project horizon considered in order to derive the present value of the flood risk.

Formula 1 A possible formula for calculating the yearly average flood risk

$$R = \sum_{i=1}^{n} \frac{1}{i}(D_i - D_{i-1})$$ with

R Expected average annual flood risk

D_x Expected damage from an inundation with a return period i

Or in full

$$R = \frac{1}{1}D_1 + \frac{1}{2}(D_2 - D_1) + \frac{1}{3}(D_3 - D_2) + ...$$ with

R Expected average annual flood risk

D_x Expected damage from an inundation with a return period i

The average annual flood risk is best calculated on the basis of the quantified impact for as many flood events as possible until the latest has no significant contribution to the annual risk any more. Furthermore, it is particularly important to determine the largest return period for which the impact more or less equals zero.[16] This especially true when only a limited number of flood events is considered. Care should also be taken with the expected consequences from very rare events (large return periods) as the hazard mapping of such events is particularly though because of uncertainty.

Risk calculations can be made for the social, economic, environmental and cultural heritage aspects. An overview of 3 different quantitative methods to define and calculate the risk can be found in the paper “Flood risk calculated with different risk measures” (Jonkman et al., 2002).

Individual risk: The individual risk is defined as the probability that an average (and unprotected) person, cultural heritage site, ecosystem, man-made infrastructure … permanently present at that location , would be affected. Locations with equal individual risk levels can be shown on a map with so-called risk contours.

Societal risk measures: Societal risk is defined by ICHEM (1985) as “*the relationship between frequency and the number of people/objects/ecosystems/… suffering from a specified level of harm”.* The basis of the calculation of societal risk is formed by the probability density function, which shows the probability of exceedance as a function of

[16] This is because the calculation method where there is a more or less linear interpolation in between consequences of different return periods would otherwise result in the overestimation of the risk if the largest return period without significant effects is not taken into account.

the number of fatalities/affected objects/… Societal risk measures are used in regulations of dams.

Economic risk measures: Economic risk measures can also be used to quantify other consequences than direct economic assets, although it can be difficult or undesired to monetize them. The problem of an acceptable level of risk can be formulated as an economic decision problem. The expected values of this risk measure are often used as a part of a cost benefit analysis (e.g. in the UK - Parker, 1987). Costs and benefits are function of the probability of failure and an optimum can be determined as the point where the sum of all investments and all damages is minimal.

An important issue is how to combine the different categories of impacts into one risk indicator, when monetary assessments have to be combined with quantitative and/or qualitative assessments. Although in the Ghent workshop many questions remained on how to evaluate impacts on the 4 different types of impact of floods, it was concluded that there are enough examples of good practice available for economic, social, ecologic and cultural heritage impacts. It is not necessary to express all aspects monetary because it is not possible (lack of data, uncertainties) or not wanted.

The **aggregation of the different categories of impacts into risk** is the most questioned problem. As a solution it is proposed to use a multi-criteria analysis (MCA) with a limited number of criteria to aggregate, easy to understand, e.g. 50% economic, and 50% intangibles (social, environmental, cultural).

These are also the key elements of the Directive to focus on. **Integration of the impacts of several return periods** (at least 3 is proposed) is needed to assess the risk, so it is very important to include maps for different frequencies and to combine the vulnerabilities or damages with the hazards to produce a risk map.

The floods and economics questionnaire (Q17) asks Member States whether and how they combine the globalised consequences of different events (with different probabilities) into risk. It turns out that only few MS combine different loss events into risk, some of them only do for high risk areas. Many MS look at each scenario separately. Examples of MS where different probabilities are integrated into a single risk indicator are AT, BE, NL, SI, UK and others, although in most cases the risk indicator is limited to economic or monetary impacts.

4.5 Knowledge gaps topic list

Knowledge gaps can be divided into 3 groups. Knowledge gaps based on:

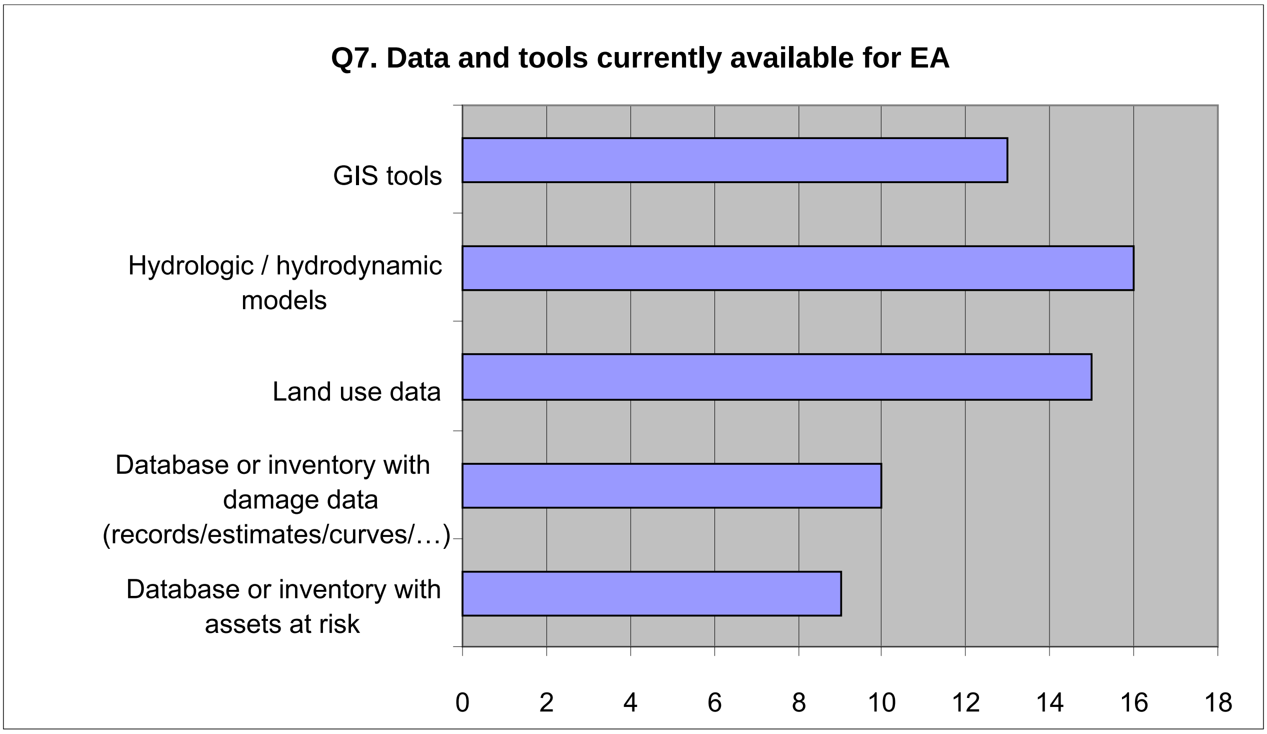
- type of flooding and relevant flooding mechanisms;
- data availability;
- methods used for the assessment.

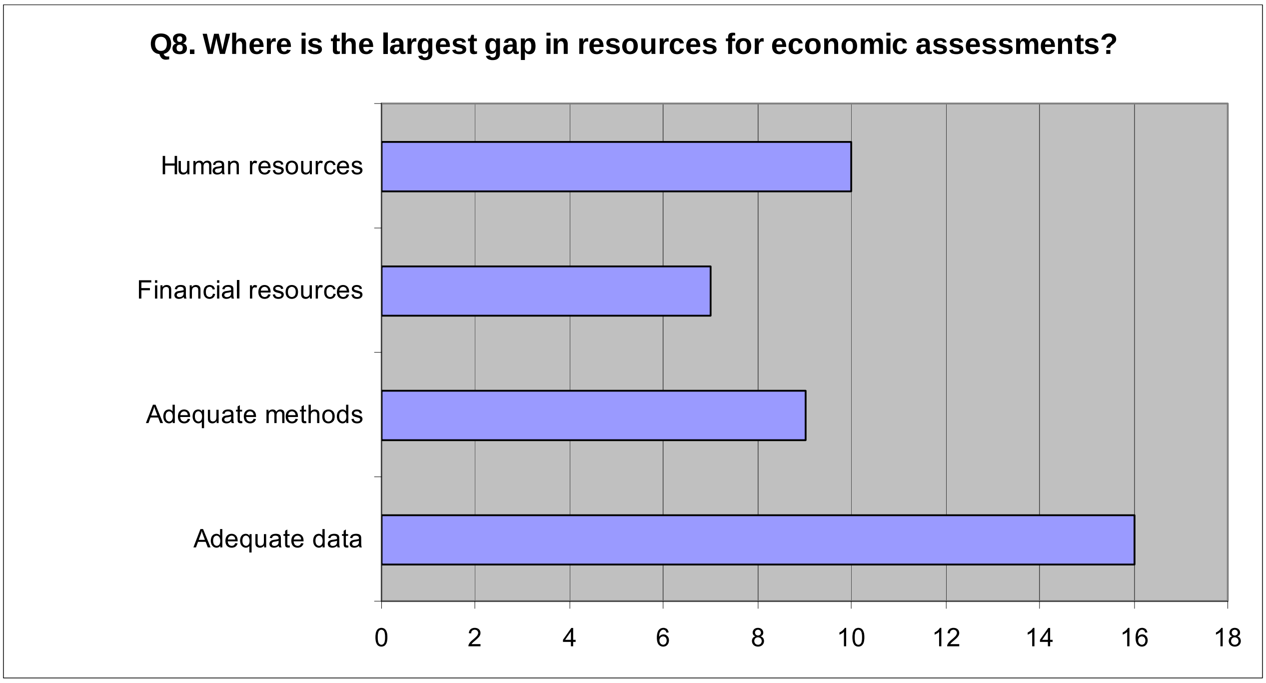
The extent to which the current limitations with respect to the assessment of flood risks are problematic depends on the objectives, and thus the required level of detail, of an assessment. A general scoping of the order of magnitude of flood risk as well as its distribution can be done by means of robust indicators, serving as a proxy. The available methods can easily support such a general scoping. Limitations with regard to such a scoping exercise mainly have to do with the input data on e.g. land use. When detailed flood risk information is required the limitations of the methods to assess the impact to indirect and intangible receptors become apparent. The Halcrow (2008) report mentions environmental impacts, impacts to human health, indirect economic losses (knock-on effects of infrastructure disruption, costs of social and business disruption and costs of loss of public services) and agricultural losses. The difficulties with assessing the impacts to this kind of receptors relates to the assessment of both the vulnerability and the value. However it is possible to value any impact, valuing intangible impacts is often resource intensive and coupled with uncertainty.

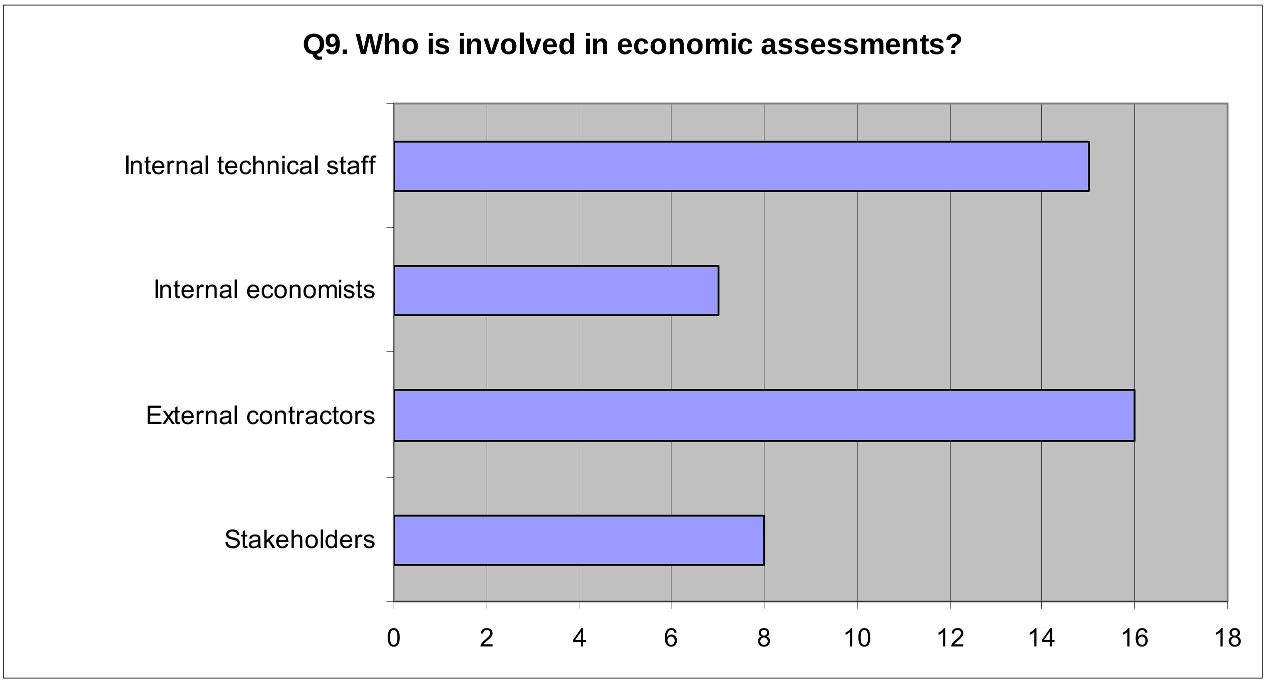
The assessment of flood risk comes down to combining the consequences for a number of flood events with the expected occurrence, frequency, of these events. Determining whether an event occurs with low, medium or high probability, like asked for in Article 6(3) of the Floods Directive generally does not pose a major problem. This, however, may turn out to be more difficult for flash floods and coastal flooding; posing different challenges for decision making. An advanced assessment of flood risk requires a much more accurate assessment of the frequency of the events studied. This is much harder as it requires a long historical record of hydrological data on the one hand and information on how climate change and human interference in the natural water system will influence flood chances. Especially the prediction of the return period of very rare events is difficult.

Reported problems in the Ghent workshop on lack of data are in the field of (indirect) effects of floods on economic activities on national or on EU level and regarding economic indicators for recovery from flooding. In more general terms it was mentioned that this resource document should not focus on data rich areas alone. It is recommended to use as much as possible existing information like results of the Floodsite project and former WG-F workshops, and to reuse available material from outside the flood community, e.g. climate change reports with information of impacts on different sectors.

On availability of data and tools the questionnaire results reveal additional information on the problems Member States face in the application of economic assessments. Most respondents (16) indicate lack of adequate data as the main gap in resources available for EA, but also adequate methods, financial resources and human resources are mentioned as being often problematic.


Q7. Data and tools currently available for EA
GIS tools
Hydrologic / hydrodynamic models
Land use data
Database or inventory with damage data (records/estimates/curves/…)
Database or inventory with assets at risk
0
2
4
6
8
10
12
14
16
18


Q8. Where is the largest gap in resources for economic assessments?
Human resources
Financial resources
Adequate methods
Adequate data
0
2
4
6
8
10
12
14
16
18


Q9. Who is involved in economic assessments?
Internal technical staff
Internal economists
External contractors
Stakeholders
0
2
4
6
8
10
12
14
16
18

5 Methods to assess the costs and benefits of measures and to prioritise measures

The Floods Directive requires flood risk management plans to take into account relevant aspects such as costs and benefits (Article 7 $3). The expected costs and benefits of measures may, however, be just one criterion for deciding about flood risk management measures and plans among several other criteria. In addition, the Directive does not stipulate how costs and benefits need to be taken into consideration. Member States can opt for a thorough cost-benefit analysis, an assessment of the cost effectiveness, freely weighing the different costs and benefits in a sort of multi-criteria analysis or any intermediate method.

The decision problem flood risk managers face is marked by uncertainty and complicated in case of transboundary river basins, requiring Member States to work together and integrate assessments. When the flood problem has been characterised potentially interesting measures have to be identified and combined into a flood risk management plan. Flood risk managers can choose among a large number of both technical and non-technical measures, the effects of which can often only be approximated. Uncertainty about the impact of e.g. climate change, evolutions in land use, the occurrence of rare events, etc. complicate any assessment. Financial constraints also force water managers to prioritise and postpone measures.

Identifying an 'optimal' set of measures is an iterative process and practically impossible in this context. Because the knowledge on the evolution of e.g. the impact of climate change, land use changes, etc. may progress over time it is believed that it may be valuable to opt for robust no regret strategies.

The challenges for Member States with respect to the assessment of the costs and benefits of measures and to prioritisation of measures are manifold. It is believed the following material would be particularly helpful for supporting Member States when assessing costs and benefits of measures and prioritising measures:

- Overview of current en expected use of evaluation methods and criteria in flood risk management by the different Member States;
- Best practise examples on the integration of public participation in the evaluation process;
- Inventory of best practises with regard to deciding under uncertainty and the development of robust, no regret measures and strategies;
- Overview of best practices for designing long term investment strategies;
- Guidance on how to practically integrate the assessments of various Member States in the case of transboundary river basins;
- Overview of methods for assessing the impacts of non-technical measures on flood risk;
- Catalogue of possible non flood risk related effects of measures and how to assess these.

5.1 Objectives of flood risk management

The objective of flood risk management is to reduce the likelihood and/or the impact of floods. The extent to which action is needed, however, depends on the objectives set by the responsible authorities. Flood risk management starts with the assessment and mapping of flood risks. Information about flood risks is the basis for developing flood risk management strategies and plans. (Halcrow, 2008) Experience has shown that the most effective flood risk management strategies and plans incorporate all of the following elements (European Commission, 2004):

- **Prevention**: preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices;
- **Protection**: taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location;
- **Preparedness**: informing the population about flood risks and what to do in the event of a flood;
- **Emergency response**: developing emergency response plans in the case of a flood;
- **Recovery and lessons learned**: returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.

The 'best practises document on flood prevention, protection and mitigation' (Water Directors, 2003), which is an update of the United Nations and Economic Commission for Europe (UN/ECE, 2000) guidelines on sustainable flood prevention, outlines a number of basic principles and approaches regarding sustainable prevention, protection and preparedness:

- As far as possible, human interference into the processes of nature should be reversed, compensated and prevented. Solutions to the flood problem should start from and respect the natural water system;
- A shift from defensive action against hazards to management of the risk and living with floods is necessary;
- Human uses of floodplains should be adapted to the potential hazards;
- Preventive and non-structural measures tend to be potentially more efficient and long term more sustainable solutions to water related problems and should be promoted;
- Flood protection, however, remains important and should primarily focus on the protection of human health and safety, and valuable goods and property;
- Everyone who may suffer from the consequences of flooding should also take his/her own precautions. To this end appropriate flood forecasting and warning systems should be established;
- Solidarity is essential, one should not pass on water management problems in one region to another. The appropriate strategy consists of a three-step approach: retaining, storing and draining;

- In flood-prone areas, preventive measures should be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and soil pollution.

To implement the above basic principles and approaches, co-operation at all government levels, and co-ordination of sectoral policies regarding environmental protection, physical planning, agriculture, transport and urban development is needed. As regards transboundary waters, co-operation is required among the riparian countries to harmonise national policies and strategies, and to draw up concerted action plans.

Integrating the objectives and insights of other sectoral policies is an important step towards / condition for sustainable flood risk management. This way decisions are also evaluated in terms of their most important side effects or non-flood related impacts (see section 3.3.4). As it may be hard to predict future developments and climate change impacts it generally is good practise to opt for robust no regret measures (see section 3.3.7). This way win-win situations with other sectoral policies should be realised.

Limiting the impact of flooding in an effective manner most often requires flood risk management to respect the natural water system. Consequently, flood risk management may be very much compatible with the objectives of the Water Framework Directive which demands that there is no further deterioration of river systems.

A first observation from the Ghent workshop is that spatial boundaries play an important role in developing objectives and economic assessments to reach these objectives: economic objectives for an individual location can differ from national objectives of risk reduction. A problem of defining acceptable risk is that it relates to the context, but it is recognised that economic assessments are able to define national objectives like levels of legal protection or appropriate boundaries for the role of different actors (spatial planners, water managers, insurers). It is questioned how far MS will define their objectives: maintain actual level of risk or go further? The minimal objective should be no further growth of risk (maintaining actual risk) taking into account future scenarios like climate and socio-economic changes. Finally it is recommended to establish multi-purpose objectives in FRM, leading to integrated FRM, and not just flood risk reduction.

5.2 Flood risk reduction measures

5.2.1 Types of measures/group of aggregated measures as agreed by CIS Working Group F

Table C2 as agreed during the 10th CIS Working Group F meeting of October 2011 describes the different types of measures that will be used for the development of the reporting schemas for the flood risk management plans.

Aspects of flood risk management	**Type**	**Description**
No Action	No Action	No measure is proposed to reduce the flood risk in the APSFR or other defined area

Prevention	Avoidance	Measure to prevent the location of new or additional receptors in flood prone areas, such as land use planning policies or regulation
	Removal or relocation	Measure to remove receptors from flood prone areas, or to relocate receptors to areas of lower probability of flooding and / or of lower hazard
	Reduction	Measure to adapt receptors to reduce the adverse consequences in the event of a flood actions on buildings, public networks, etc...
	Other prevention	Other measure to enhance flood risk prevention (may include, flood risk modelling and assessment, etc...), maintenance programmes, flood vulnerability assessment
Protection	Natural flood management / runoff and catchment management	Measures to reduce the flow into natural or artificial drainage systems, such as overland flow interceptors and / or storage, , enhancement of infiltration, etc. and including in-channel , floodplain works and the reforestation of banks, that restore natural systems to help slow flow and store water.
	Water flow regulation	Measures involving physical interventions to regulate flows, such as the construction, modification or removal of water retaining structures (e.g., dams or other on-line storage areas or development of existing flow regulation rules), and which have a significant impact on the hydrological regime.
	Channel, Coastal and Floodplain Works	Measures involving physical interventions in freshwater channels, estuaries, coastal waters and flood-prone areas of land, such as the construction, modification or removal of structures or the alteration of channels, sediment dynamics management, dykes, etc.
	Surface Water Management	Measures involving physical interventions to reduce surface water flooding, typically but not exclusively in an urban environment, such as enhancing artificial drainage capacities or though sustainable drainage systems (SuDS).

	Other Protection	Other measure to enhance protection against flooding, which may include flood defence asset maintenance programmes or policies
Preparedness	Flood Forecasting and Warning	Measure to establish or enhance a flood forecasting or warning system
	Emergency Event Response Planning, Contingency planning	Measure to establish or enhance flood event institutional emergency response planning
	Public Awareness and Preparedness	Measure to establish or enhance the public awareness or preparedness for flood events
	Other preparedness	Other measure to establish or enhance preparedness for flood events to reduce adverse consequences
Recovery and Review i)	Individual and societal recovery	Clean-up and restoration activities (buildings, infrastructure, etc.) Health and mental health supporting actions, incl. managing stress Disaster financial assistance (grants, tax), incl. disaster legal assistance, disaster unemployment assistance Temporary or permanent relocation
	Environmental recovery	Clean-up and restoration activities (with several sub-topics as mould protection, well-water safety and securing hazardous materials containers) Other
	Other recovery and review	Lessons learnt from flood events Insurance policies
Other		

5.2.2 Types of measures/group of aggregated measures compiled by Arcadis[17]

Table 2, developed by Arcadis, provides an overview of flood risk reduction measures. Each measure is characterised in terms of all aspects of flood risk management as presented in alinea 3 of Article 7 §3 (focussing on prevention, protection, preparedness, emergency response and/or recovery and lessons learned) on the one hand and the components of flood risk it acts on (flood hazard, value and vulnerability) on the other hand.

[17] Based on : Water Directors of the European Union (2003) and Flooding Issues Advisory Committee (2007).

Another classification of flood risk reduction measures denotes measures as either green, grey or soft. Green and grey measures have a direct physical impact on the environment. Green measures seek to restore or maintain the naturalness of the river system and the catchment while grey measures point at hard engineering constructions often aimed to protect properties locally. Soft measures denote instruments like economic incentives, information and rule- and law-making.[18]

Table 2 Catalogue of measures

[18] Interesting information on the division structural / non structural and issues like efficiency and effectiveness can be found on http://www.crue-eranet.net/publications.asp where detailed project reports and a summary report can be found of the CRUE 1st common funding initiative.

N°	Measure	Alinea 3 of Article 7 (3) of the Floods Directive					Flood risk component			Green, grey and soft		
		Prevention	Protection	Preparedness	Emergency response	Recovery and lessons learned	Flood hazard	Value	Vulnerability	Green	Grey	Soft
1	Conserve, protect and, where possible, restore vegetation and forest in mountainous areas, riparian woodland and meadows	x					x			x		
2	Conserve, protect and, where possible, restore degraded wetlands and flood plains	x					x			x		
3	Reconnect of floodplanes to the river by e.g. relocating dykes, opening natural levees, …	x					x			x		
4	Conserve, protect and, where possible, restore the naturalness of watercourses, including river meanders	x					x			x		
5	Conctruct areas for controlled flooding	(x)	x				x			x	x	
6	Dismantle manmade bottlenecks of flow	x					x			x		
7	Construct and/or heighten dikes		x				x				x	
8	Construct (mobile) flood protection walls and closures		x				x				x	
9	Conserve, protect, heighten and develop sandbanks	x	x				x			x	(x)	
10	Conserve, protect and heighten sand dunes	x	x				x			x	(x)	
11	Construct dams		x				x				x	
12	Construct breakwaters		x				x				x	
13	Construct storm-surge barriers		x				x				x	
14	Pumping		x				x				x	
15	Dredging		x				x				x	
16	Increase the capacity of sewer systems and remove bottlenecks		x				x				x	
17	Uncouple waste water and rain water drainage systems		x				x				x	
18	Augment storage capacities in the rain water drainage system	(x)	x				x			(x)	x	
19	Straighten watercourses for improving their conveyance		x				x				x	
20	Sandbagging		x				x		x		x	
21	Ban construction in risk area	x						x				x
22	Flood proofing of buildings, constructions and utilities	x							x			x
23	Relocate activities and buildings	x						x				x
24	Limit soil compaction and sealing	x					x			x		x
25	Promote rainwater infiltration	x					x					x
26	Stimulate year-round vegetation cover	x					x			x		x
27	Stimulate rainwater storage and grey water use	x					x			x	x	x
28	Flood risk modelling and assessment	x	x	x	x		x	x	x			x
29	Flood forecasting and early warning systems			x	(x)		x	x	x			x
30	Risk communication and education	x		x			(x)	x	x			x
31	Inform and teach people what to do before, during and after a flood			x	x	x		x	x			x
32	Insurance	x				x		x	x			x
33	Establish a compensation system for supporting victims					x			x			x
34	Develop contingency plans				x		x	x	x			x
35	Train contingency plans				x		x	x	x			x
36	Evacuation				x			x	x			x
37	Provide assistance before, during and after a flood		x	x	x	x	x		x			x
38	Provide psychological support					x			x			x
39	Carry out research, draft and exchange lessons learned and disseminate results	x	x	x	x	x	x	x	x			x

This table can be complemented by the following measures:

- adaptive lake/water course regulation (prevention)

- flood prevention/protection rehearsals (preparedness)

Preventive flood risk management seeks to conserve, protect and, where possible, enhance the local natural storage capacity of nature (vegetation, soil, ground and wetlands) as well as the degraded wetlands, natural flood zones and watercourses. It is also about ensuring land uses that are appropriate to areas prone to flood and erosion, enhance soil conservation by avoiding excessive soil compaction and erosion, develop a network of agricultural roads and practices such as contour tillage which would take into account water retention objectives and ecological requirements, and change the vegetation cover (grassing of river banks and flood plain areas, convert arable land into pasture-land).

Flood prevention has the merit to generate ecological benefits in the form of maintaining biodiversity, recharge underground aquifers, promote cleaner water for drinking, create areas for recreation, etc. The maintenance and/or enhancement of the naturalness and vegetation edging of watercourses is both respectful of the wealth and biodiversity of these environments, and effective against the risk of flooding. This leads at the same time to a reduction in nutrient and pesticide input into rivers. Preventive flood risk management is likely to contribute meaningfully to reaching the objectives of the Water Framework Directive.

Given the current evolution towards integrated flood risk management in Europe, it would be especially important to further investigate the potential of flood mitigation measures. While it is increasingly acknowledged that technical flood protection needs to be accompanied by protection measures on the level of individual buildings and businesses, the damage-reducing effect of such measures is still largely unknown. Insights into these aspects are important, because they allow to evaluate and to choose between various risk mitigation strategies. This seems to be especially important against the background of the projected increase in flood risk in many places due to climate change and increased vulnerability. (Bubeck and Kreibich, 2011)

Ghent workshop participants concluded that most solutions will consist of a mix of measures, due to limitations of budget and space to develop risk reduction measures. The tools should be able to manage these interactions. The effects of non-structural measures like flood warnings on risk reduction are more difficult to evaluate.

In the Floods&Economics questionnaire six MS indicated to have experience with the economic assessment of non-structural measures, but existing information and data to do so is limited.

References to lists of measures were delivered by different respondents:

wasser.lebensministerium.at/article/archive/14407

environnement.wallonie.be/de/dcenn/plan_pluies/actions.htm

German LAWA documents

Annex to the Spanish Royal Decree 903/2010 that transposes the Directive 2007/60/EC.

www.mma.es/portal/secciones/aguas_continent_zonas_asoc/prevencion_inundaciones/

www.inondations.lu

www.likumi.lv/doc.php?id=201369

Slovenian Water Act (Ur.l. RS, št. 67/2002); Protection Against Natural and Other Disasters Act (Ur.l. RS, št. 64/1994); Spatial Planning Act (Ur.l. RS, št. 110/2002

http://www.defra.gov.uk/environment/flooding/funding/targets.htm

http://www.environment-agency.gov.uk/research/planning/122070.aspx

5.3 Prioritisation of flood risk reduction measures: appraisal methods and criteria[19]

Article 7 (2) of the Floods Directive stipulates that the flood risk management plans be developed should focus on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity. This requires decision making about flood protection to integrate and balancing the different effects of flooding. At the same time the second paragraph of Article 7 (3) of the Floods Directive requires flood risk management plans to take into account costs and benefits. This could be interpreted as meaning that the costs of measures or flood risk management plans should not be disproportionally high compared to the associated benefits. The appropriateness of simple CBA ratios in flood risk management decision making, however, still needs to be further explored.

Integrating different kinds of effects and balancing costs and benefits requires the use of an appropriate appraisal method. The assessment frameworks cost benefits analysis (CBA), cost effectiveness analysis (CEA) and multi-criteria analysis (MCA) are introduced below, highlighting their main advantages and disadvantages in comparing different options or alternatives. To conclude extended CBA is proposed as an alternative framework, combining the best of CBA and MCA.

In Ghent, several examples of good practices with appraisal and prioritisation methods were presented.

Presentation by Cédric Peinturier (abstract 7): Reviewing cost-benefit methodologies used in France to optimize FRM. A full paper is available as well. Since 2007, the Ministry in charge of Sustainable Development has established a process to develop the practice of economic analysis in the field of flood risk prevention. This type of analysis will soon be mandatory for asking for public financing of flood risk prevention action plans. In the presentation the background of the method was explained in detail. A large number of damage functions is used, where difference is made in between slow and fast floods.

[19] Based on: Brouwer and van Ek (2004), Meyer et al. (2007), Florio et al. (2008), De Smet (2010b) and Crabbé et al. (2006).

Presentation by Urs Nigg (abstract 8): “EconoMe” An Online-Tool for Cost-benefit calculations of FRM measures in Switzerland. “EconoMe” enables the planning engineers, investors and authorities (at different levels) responsible for avalanche, flood, slide, unconfined debris flow and rockfall processes to carry out comparative cost-effectiveness analyses. The comparability is ensured through the definition of conventions for the requisite parameters. The cost-benefit studies are used to prioritise measures. The presentation started with the theoretical approach explaining the methodology behind the tool. The second part was about the tool itself and the results of some applications. More information is available on www.econome.admin.ch.

Presentation by Olli-Matti Verta (abstract 9): “Multi-Criteria Decision Analysis (MCDA) in the evaluation of the flood risk management alternatives – the Kokemäenjoki River Basin case”. A full paper of this work is available. Based on a case study a MCDA method was shown to prioritise flood risk management measures in a river basin scale flood risk management plan. Potential evaluation criteria and how to weight them were explained.

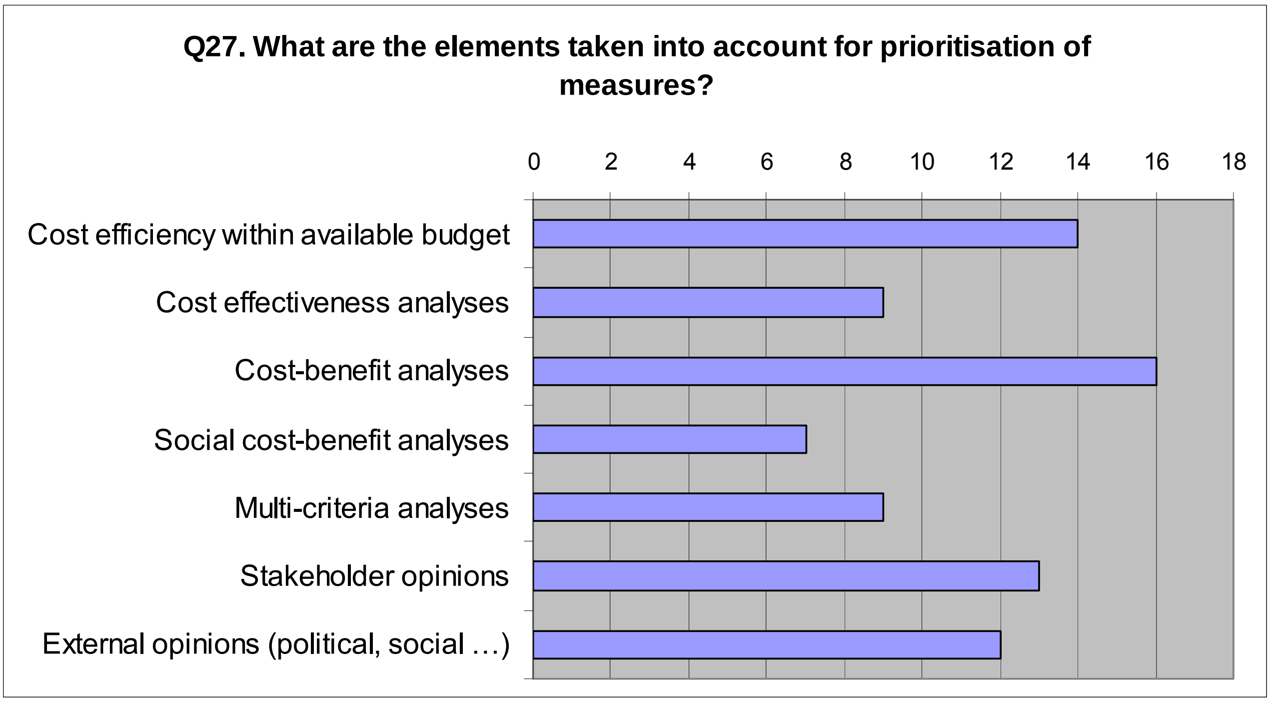
Presentation by Jarl Kind (abstract 10 and full paper): “Efficient Flood Protection Standards based on cost benefit analysis”. The cost-benefit analysis uses a dynamic model to determine an optimal investment strategy in dike reinforcement. This strategy minimises the discounted investment cost and residual flood damages over a longer time horizon where economic growth and climate change affect the level of flood risk. Final results weren’t available at the time of presentation, but ample attention will be given on difficult subjects such as the valuation of immaterial damages (including the value of statistical life), indirect damages and the issue of discounting. The methodology behind is showed in this presentation.

Presentation by Peter Hanisch (abstract 11): “Introduction of new Guidelines and Tools for Cost Benefit Analysis (CBA)”, further explained in a full paper. The presentation gives an overview of the legal framework to work within and the different components in the CBA. The lessons learned or experiences with the new CBA analysis guideline since 2008 were explained. These can help to identify the approaches and methodologies which should be homogenised among the European countries and which parameters should be left to be established on a regional level.

Presentation by Ann Kathrin Buchs (abstract 12): “Economic Assessment for Implementing Flood Risk Management – case study of Lower Saxony – lessons learned from WFD” (full paper on CIRCA). The lessons learned show that economic assessments as e.g. the cost-efficiency of measures has to be approached in a broader context, not only with the application of theoretical methods as the cost-benefit-analysis. The constitution of institutions, structures and processes and the mechanisms that influence their actions play an important role to support and ensure an efficient outcome of economic assessments. The presentation contains several ideas for further proceeding, like strengthening of existing structures and procedures rather than working on new mechanisms or regulations, cooperation with specialised institutions, exchange of experience with practical application of EA methods and identification of transnational needs on data and knowledge. These findings based on WFD implementation are also transferable for the implementation of the Floods Directive.

Presentation by Leo De Nocker (abstract 13): “The use of social cost-benefit analysis for flood protection analysis in Flanders”. Costs, benefits and co-benefits for different alternatives and how to quantify them were explained using the Sigmaplan for the river Scheldt as a case study.

The questionnaire responses give an idea of the use of appraisal and prioritisation methods throughout Europe.



Annex 6 comprises key Member States links to appraisal methods of measures like reported in the questionnaire.

5.3.1 Cost benefit analysis

5.3.1.1 What?

A CBA is an economic evaluation method by which current and future costs and benefits of policy alternatives, projects, actions or realities – for reasons of simplicity we will hereafter refer to 'alternatives' – can be compared in monetary terms. It is a method on the basis of which one can judge whether the benefits of an alternative outweigh the corresponding costs. A CBA provides an indication of the net welfare effect of an alternative.

The usual criterion for the evaluation of projects in a cost-benefit framework is the Net Present Value (NPV). The NPV is defined as the sum of discounted benefits minus the sum of discounted costs over the lifetime of a project. An alternative cost-benefit criterion is the Benefit-Cost Ratio (BCR), which is the ratio of discounted benefits to discounted costs. A BCR > 1 indicates a positive impact of the project on welfare, similar to a NPV > 0. But in contrast to the NPV, the BCR does not measure the total impact of the project on social welfare but the relation of its benefits to its costs. The choice whether the NPV or the BCR should be used depends on the decision situation. If e.g. one project should be chosen among a set of options then the decision rule would be to choose the one with the highest NPV. If, on the other side, capital budget is fixed and several projects should be carried out with this budget the right decision rule would be to rank the projects by their BCR and accept them in order of their ranking until the budget is exhausted (Bubeck and Kreibich, 2011).

5.3.1.2 Advantages and disadvantages

An important advantage of a CBA is that it builds on solid theoretical foundations, which do provide the necessary consistency to a CBA. Because a CBA has its roots in welfare economics it is perfectly suited to compare totally different alternatives; costs and benefits are all expressed in the same unit: money.

Opposition to the use of CBA often has to do with the difficulty to express certain effects in monetary terms. Irrespective of the clear progress with respect to the monetary valuation of certain effects its results are still subject to discussion. Another drawback of a CBA is that this method largely neglects the division of costs and benefits among different groups and generations. In order to overcome this, some specific focus or breakdowns could be done on the economic impact of the measure for these groups and generations.

The use of CBA was discussed in the Ghent workshop. In some MS CBA is mandatory to get funding. A disadvantage is that in case the outcome of CBA turns out to be negative, certain measures will never be taken into account. If CBA is used one should take notice of the scale and circumstances to what it is applied. For small or relatively cheap measures a CBA can be inefficient (relatively expensive). CBA is a useful tool to raise awareness and can be included in communication. By monetising social preferences (willingness to pay), CBA is able to deliver information to discuss on a societal level the values that should be protected. Co-benefits are difficult to estimate and there is not much experience with quantification and valuation. Care should be taken not to include emotional aspects in the basic figures. MS use different criteria in their decision frameworks. Comparable numbers are most probably number of properties and number of people. But once these assets are valuated in order to include them in CBA, the comparability becomes less. An observation is that the biggest part of a catchment sets the criteria for the decisions.

5.3.2 Cost effectiveness analysis

5.3.2.1 What?

A CEA is used to compare the costs of alternatives to the corresponding impacts. The effectiveness of a flood prevention policy can be expressed in terms of the decreased flood risk, extra storage capacity created, etc. By linking the effectiveness to the corresponding costs one gets an insight in the cost effectiveness of the alternatives considered. A CEA provides an idea of the cost against which the objectives can be realised.

5.3.2.2 Advantages and disadvantages

In contrast to a CBA a CEA does not require monetising the consequences of measures. The impacts or effectiveness can be expressed in a different unit. This implies that a CEA can only be used to compare, and thus rank, measures/alternatives that are formulated in terms of the same objectives. It is often advisable to also consider the most important side effects of an alternative. However, if these cannot be expressed in the same unit as the core objectives it is impossible to make an integrated assessment by means of a CEA.

5.3.3 Multi-criteria analysis

5.3.3.1 What?

A MCA is a generic term for a number of methods that use multiple criteria for evaluating alternatives. These criteria are usually related to the objectives and points of attention of the policy makers and stakeholders. All projects or alternatives considered get a value for the evaluation criteria considered. The importance of the different evaluation criteria is fixed. Finally, a general score can be calculated or derived by means of a weighted summation of the values for the evaluation criteria. The scores for the different alternatives allow ranking the alternatives considered.

5.3.3.2 Advantages and disadvantages

The advantage of an MCA is that it can be applied in complex situations. Compared to a CBA it is also possible to account for the effects that cannot be monetised easily. A MCA can handle quantitative (and thus also monetary) as well as more qualitative information. It thus offers a practical framework for dealing with dissimilar information in an equal way.

Just like a CBA, a MCA translates complex information into a clear outcome. Even more than is the case with a CBA it, to this end, allows to make the deliberations and interests of the stakeholders involved more visible. To the extent that the values accorded to the alternatives are derived in an objective, reproducible way on the one hand and all steps of the MCA are well documented on the other hand, a MCA contributes positively to the overall transparency of the decision (making process). In addition, a MCA leaves quite some room for stakeholder participation.

A MCA ranks the alternatives, but does not tell whether the alternatives are desirable from a welfare point of view. It is not clear whether the alternatives create or destroy welfare; and thus should be selected or not.

The outcome of a MCA depends to a large extent on the choice of the evaluation criteria, the potential weights attributed to the evaluation criteria and the methods for determining the value of the alternatives for the evaluation criteria considered. The choice of the weights to be attributed to the different evaluation criteria often requires a political decision. Experience, however, learns that the outcome of a MCA often remains susceptible for discussion even when due consideration is given to the opinions of the stakeholders.

The MCA should be seen as participation method to create collaboration between stakeholders. The main benefit of MCA is not in the outcome but in the process. The MCA enables systematic and transparent evaluation and provides common ground for the stakeholders for planning further recommendations.

A lot of ideas on MCA were discussed in the Ghent workshop:

- It is recognised that the weighting in MCA is a way of engaging stakeholders, but is also a political issue. The policy makers should decide on the importance of the different parameters. Assigning weights is very subjective, and also a way to manipulate the results of MCA, like there are also many ways to manipulate results of a CBA. As a result of this inherent subjectivity, there are no right or wrong weights for the evaluation criteria. People representing different interest groups have different perspectives and values and thus it is natural that they may give different weights for the criteria. One advantage of MCA is that it can explicitly describe these differences.

- It would be a good practice to use a few criteria weight profiles in the evaluation of alternatives. These profiles can be based on stakeholder opinions or they can be hypothetical and represent different potential perspectives (generated by experts) to the decision situation. The MCA tool could be used to propose different scenarios that are based on different weights of the criteria and propose them in this way to the politicians, in order to make the impact of these changes transparent. This can be seen as one way to do the sensitivity analysis and to analyse the importance of the criteria weights to the outcome of the process.
- A MCA should be adaptable, by changing the parameters that could be changed within the next years.
- It is recommended to use a MCA to score the different impacts (economic, cultural, social, environmental) in order to combine them into global risk assessments. The use of the same criteria as the ones of the PFRA and of the risk maps will make this process more consistent and will avoid double work.

5.3.4 Extended cost benefit analysis

This decision framework prioritises the use of monetised effects but offers a MCA based framework for presenting and dealing with non-monetary information in a balanced way as to make sure decisions are made on all information available. An extended CBA thus offers a framework for dealing with multiple information. This decision framework combines the advantages of both a CBA and a MCA. It is a MCA framework that encompasses a CBA.

Although most MS use CBA as prioritisation method, while MCA is rarely used, Ghent workshop participants recommend to integrate both CBA and MCA within the general decision framework (see point 3.1), in order to combine all monetary and non-monetary expressed impacts of floods and of measures to reduce flood risks.

5.4 Knowledge gaps

Deciding between different flood risk reduction measures or management plans requires dealing with uncertainty. Better decision making would require reducing uncertainty or adopting better ways to decide on the basis of uncertain information. Increasing the number of effects that is effectively accounted for is a good strategy if these effects can be assessed relatively well. The various sources of uncertainty are well-known, but their quantification if often very difficult. Progress in this respect would be very helpful, but would require better knowledge of the receptor’s studied. Another source of uncertainty is the effect of climate change on flood risk.

Developing a system for charging the beneficiaries of flood risk reduction measures requires proper knowledge of the impact of various actions on flood risk. In many instances the available methods do not allow supporting such a system as they are not suited for micro scale analyses and/or are not accurate enough.

6 Financing flood risk management and the role of insurance systems[20]

There currently is an increasing gap between what flood risk managers can do from existing public funds and what the public wants them to do. The demand for safety outstrips the capacity of governments to deliver it. The effects of climate change are expected to increase funding needs. Likewise both the increase of value in flood-risk-area and land use changes (speeding up the drainage of water e.g. because of the increased impermeability of the soil) may also increase flood risk and consequently the demand for flood risk reduction.

Preventing a further increase in flood risk is believed to be an important task for governments. Construction in flood prone areas could be avoided, natural flood areas could be safeguarded, the increase in the impermeability of soils could be prevented or limited, etc. Realising such objectives requires a proper legal framework and incentives to promote decisions by families and economic actors that are in line with the principles of preventive flood risk management.

At the individual or private level a properly designed insurance scheme can be very useful with respect to preventive flood risk management. In order to prevent people from erecting new constructions in risk area as well as provide incentives to stimulate property owners to better manage the flood risk to which they are exposed themselves it is believed to be important that insurance premiums reflect local flood risk. Insurance premiums are lower for properties that are not or barely at risk. On the opposite, as a side effect, actuarial premiums may lead people not to insure their goods, because the premium is too high if so is the risk. They become then more vulnerable to floods, as they are not covered by insurance. When new defences are built, when owners or tenants sign up to flood warning service and fit measures such as flood boards then the flood risk is reduced. Insurance premiums could be adapted (lowered) in order to stimulate people to take action. This kind of incentive makes people better aware of the flood problem and stimulates personal action; flood risk is limited through increasing people’s preparedness and coping capacity. But when considering the effect of government spending on flood protection you get the strange effect that people that are protected better (with public money) pay less insurance while those not helped with public money pay the same amount as before or even more from a relative point of view.

Reference should be made here to the concept of “total loss control”, which means integrating and optimising the average annual costs of disaster losses and prevention measures. The main risk management issue in this concept is a balancing out of financial resources, on a yearly basis, between risk reduction measures and risk transfer measures, with as much long-term perspective as possible considering the volatility of flood hazards.

To date flood risk management (e.g. a particular flood protection scheme) has the characteristics of a public good as people cannot be excluded from its benefits. Flood risk management, however, is a valuable service. The beneficiaries are generally not charged for this service as determining the extent of benefit derived by any particular beneficiary from a flood management project is not easy. This is a major reason why flood management projects are usually financed by governments. A more accurate

[20] Based on EA (2009a); EA (2009b); World Meteorological Organisation (2007)

assessment of the likely benefits of a flood risk reduction scheme to individuals opens up the possibility for asking a contribution from the beneficiaries of a flood risk reduction measure or management plan. This contribution can be asked for upon completion of the project and/or periodically to cover the costs of operation and maintenance. Similarly, actions that do contribute to the flood problem can be taxed to the extent they increase the problem.

Recently the UK Environment Agency introduced a new policy to get contributions from private, public or voluntary organisations or communities that benefit most from planned work by the Department of Flood and Rural Affairs, Department for Communities and Local Government and the Regional flood defence committees. The objectives are to:

- Get contributions from private, public or voluntary organisations or communities who will benefit most from planned work;
- Make sure that these contributions reduce the costs for creating, extending and maintaining planned assets and services. This will allow the authorities that manage flood risks to do more than they would otherwise be able to do;
- Obtain contributions where new housing or commercial development or regeneration requires changes in the existing flood risk management assets or service arrangements. These contributions will cover the cost of creating, extending and maintaining the required assets or services;
- Look for contributions from major existing beneficiaries where planned measures will further reduce the risk of flooding. These contributions will be in proportion to the benefits received;
- Do more work in partnership with others.

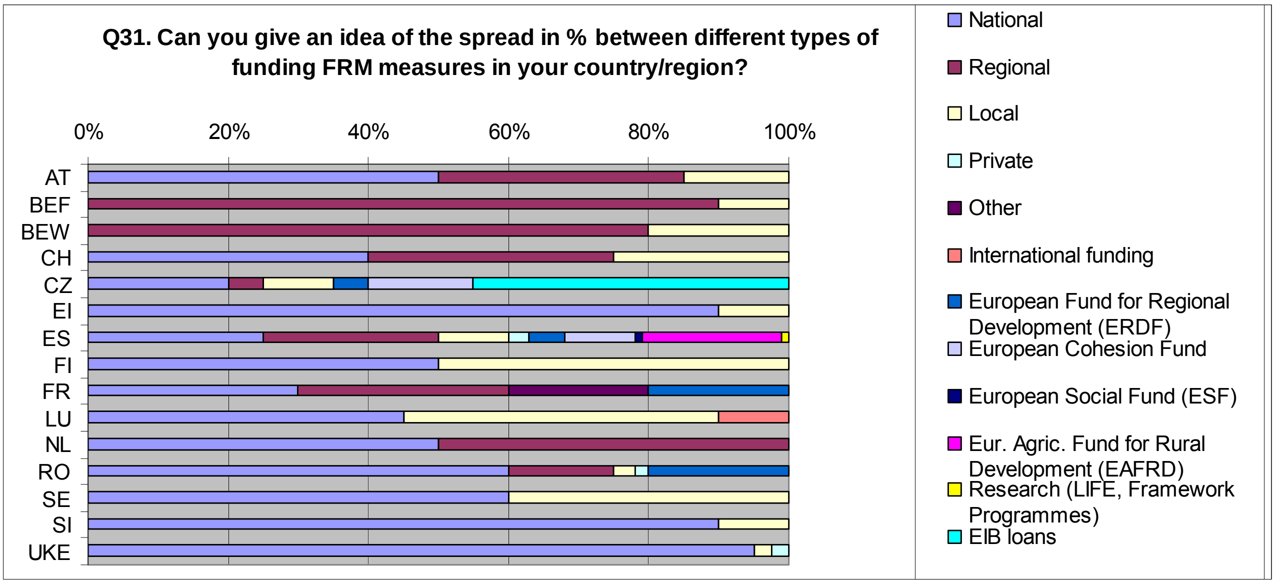
Once beneficiaries come to know that they have to pay for the schemes, they would themselves moderate their demand for flood risk reduction measures or management plans which cannot be justified on economic grounds. This strategy is expected to limit 'overconsumption' of costly flood protection measures and to stimulate alternative flood risk management measures people can take themselves. This way the gap between what flood risk managers can do from existing public funds and what the public wants them to do is expected to decrease. In addition, the available funds to the flood risk management authorities are increased by local contributions.

Instead of asking contributions from private or public actors for a planned decrease in flood risk the inverse is also possible; taxing actions that do contribute to the flood problem. Some possible action may be to charge an increase in the impermeability of the soil by new constructions, new constructions in flood risk areas, the occupation of natural flood areas, nonconformity with various regulations.

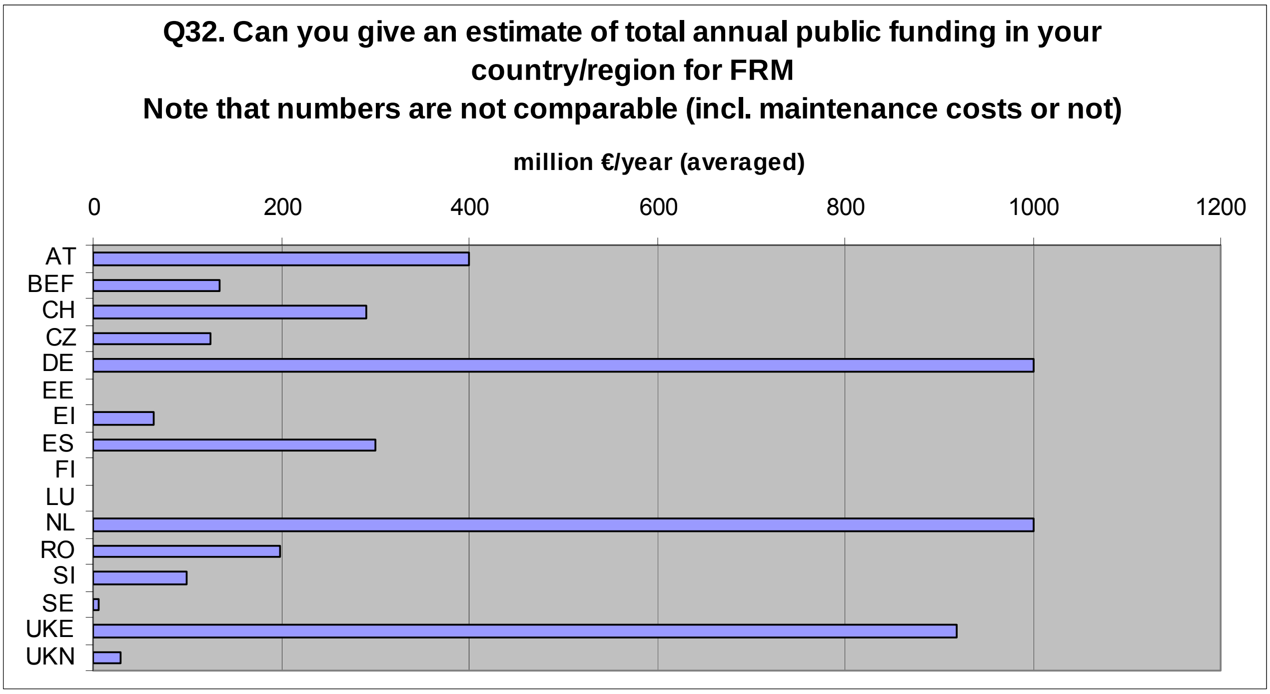
The methods for financing flood risk reduction measures can also be catalogued. Table 9 contains a draft fact sheet for characterising different methods for financing flood risk reduction measures.

The floods and economics questionnaire asked for sufficiency of existing resources for financing measures to reduce flood risks. One observation is that in some MS there is a large gap between available budget and needed resources for FRM, even after budgets have been raised significantly due to flood events. Other MS indicate that due to political pressure available funds are sufficient, and human resources becoming the limiting factor for planning and executing FRM projects. Another observation is that we will have to wait for the outcome of the first FRMPs to be able to give a clearer view on sufficiency of budgets, but the general idea is that financial resource gaps will increase in the future. In case of insufficient resources or financial restraints, measures will have to be postponed in time, or new financing mechanisms will have to be put in place. Due to a more preventive approach of FRM and the raising of awareness for resilience actions, national public funding is replaced gradually by local and private funding, making use of solidarity funds or more direct contributions from beneficiaries. Support by EU funding is in many cases invoked as essential.

Question 31 asked for the spread in % between different types of funding FRM measures.



Question 32 asked for the amount of total annual public funding for FRM.



The Ghent workshop participants concluded that in selecting measures it is important to look at who will bear the costs: the authority for risk reduction measures, or the public for insurance fees or resilience measures. The possibilities for cost recovery of measures depend on who takes the initiative. There is a clear difference between national and local authorities who work on different scale levels.

The Stirling workshop participants stressed the necessity to establish the user-pay principle, whereupon beneficiaries make a contribution towards flood management/flood protection.

Based on the questionnaire results, subsidies for private investments are rare throughout the EU. Some MS mention examples of subsidising private initiatives when they contribute to reduction of flood risks. There are examples in a few MS where authorities pay or subsidise initiatives within nature conservation areas having (co-)benefits for flood risk management. Other MS consider introducing such practices. Within agricultural or forest areas such payments take form of damage compensation for using these areas as flood retention area or of subsidies for constructing flood reservoirs. Local opposition, demand for protection and legislative constraints are mentioned as problems to overcome.

Only a few examples of cost recovery for FRM are mentioned, where local drainage boards or local water authorities charge to land owners or inhabitants their expenses to reduce flood risks. Payments for insurance premiums are also seen as an example of cost recovery for damage repair. Most MS indicate not having a system of cost recovery, but many are thinking about it and suggest a bigger role for payments by beneficiaries, directly which is still difficult to achieve, or indirectly making use of a solidarity fund.

Only 3 respondents indicate having a system of levies to finance FRM measures, but these systems are limited to local management levels.

Insurance systems

There is a need to review the traditional role of the state as global insurer for damages from natural events and its role as sole bearer of costs for protective measures, and to redistribute responsibilities. It is also important for the state to ensure that risk taking behaviour is discouraged by ensuring, where possible, that individuals do not undertake risky actions in the expectation that the state will then intervene. For this, the role of the insurance sector is crucial. There is a need to explore further private public partnerships between the insurance sector and the state to determine the threshold where state guarantees are needed, i.e. damage levels that are not privately insurable. A large number of insurance mechanisms are possible, which need to be properly explored to ensure appropriate cover from natural events while protecting the fiscal stability of the state[21].

Carmen Bell (CEA, abstract 18) gave a presentation in the Ghent workshop on the European insurance industry's experience. The presentation is accompanied by a paper available on CIRCA. Floods economics is central to the European insurance industry.

[21] Article 100.2 of the Treaty of the European Community refers to solidarity provisions between Member States in the event of a major natural catastrophe affecting the economy of one or more Member States.

There is no one-size-fits-all solution and the overarching principle indisputably is "responsibility sharing" as it increases risk awareness, reduces moral hazard and enhances risk reduction measures. Effective flood risk management requires coordinated action, aiming at an optimal combination of stakeholder's expertise and strengths where ex-ante financing schemes can boost efficiency.

Although the impression existed during the workshop discussions that the insurance industry is specialised in pay-outs for damage relief, insurers consider themselves as an integral part of the entire risk management cycle, including not only risk transfer, but also risk identification methods such as flood risk mapping and assistance to public authorities in the set-up of appropriate risk management frameworks (e.g. risk modelling initiatives to predict the cost of risk). Risk assessments by the insurance industry can be questioned: not all insurers have adequate engineering capacity, e.g. for taking into account the effects of structural defences. For this reason they need insight in the effects of FRM measures on the risk. Exchange of data from the water managers is a matter of survive for the insurers: they don't want to lose their clients.

The role of insurers is to transfer risk to many; the exclusion of individuals from insurance seems to be contradictory. However, there may be reasons why a particular individual cannot be insured. Individuals who fail to take appropriate precautions, such as building in flood-prone areas against building codes or advise of public authorities, building without proper construction permits, or lack of maintenance, make it increasingly more difficult for their properties to become or remain insurable. There will always be some properties whose flood risks are so severe that they cannot be insured at an affordable premium. In many Member States there is a trend towards Public Private Partnerships which aim to improve the insurability of natural catastrophes so that more individuals may be covered. Additionally, as stated by the CEA, the pricing of an insurance product (both the premium rate and the deductible levels) may not be able to reflect the existing level of the risk if it is required to be made affordable to the public.

Insurers can only play a role when risk can be calculated; in the case of the New Orleans event the lack of channel maintenance and engineering negligence was seen as the responsibility of the administration. Increase in risk leads to higher premiums on the long term, this is not always caused by a single flood event. Uninsurable risk means risk beyond financial capacities of (re)insurers. It is also questioned that insurers can play a role in relief from intangible effects of flooding, as well as enhancing source related measures.

Workshop participants recommended to work on good relations with the insurance industry, and to look for transparency and data exchange in both directions, also on which risks are uninsurable. Also stakeholders like land use planners and water power plant managers should be engaged in the exchange of information on risks. When more information becomes available in the public domain it can provide "ammunition" for the MS. The possible consequences of climate change should strengthen the need for collaboration. Care should be taken for transparency to the public and to make as much as possible data public.

From the questionnaire results, most MS seem to have a working insurance system. Some are mandatory in combination with property insurance, others not. In many cases the insurance system is backed by a national fund for indemnities that are not covered by private insurers. The solidarity principle is applied where also people living outside risk areas contribute. In high risk areas premiums are higher, or properties become even uninsurable. Premiums are reflecting risk levels more with improving data on risks.

EU funding

The Ghent workshop presentation of Maria Brättemark (DG ENV) on EU funding gave an overview of some key instruments and questions for the future but not worked-out plans for the post 2013 era. Funding mechanisms described are: cohesion policy funding, rural development policy, Pre-Accession and Neighbourhood policy, Civil protection financial instrument, EU solidarity fund, Life and Critical infrastructure financial instrument. A draft catalogue and some overview per instrument are given at the end.

The role of EU funding differs largely between MS (see also questionnaire results). The actual GDP criterion for ERDF funding is not clear (what are the reference MS to determine the 85% of GDP limit?) and limits the application to very few countries. ERDF Pillar II should play a role in the EU2020 climate change adaptation strategy. It is questioned if GDP will stay the critical criterion in the next funding period from 2014 on. Possible new criteria could be climate change adaptation, the solidarity principle between all MS (ETC is now restricted to overall EU borders), and areas of potential significant flood risk in all MS.

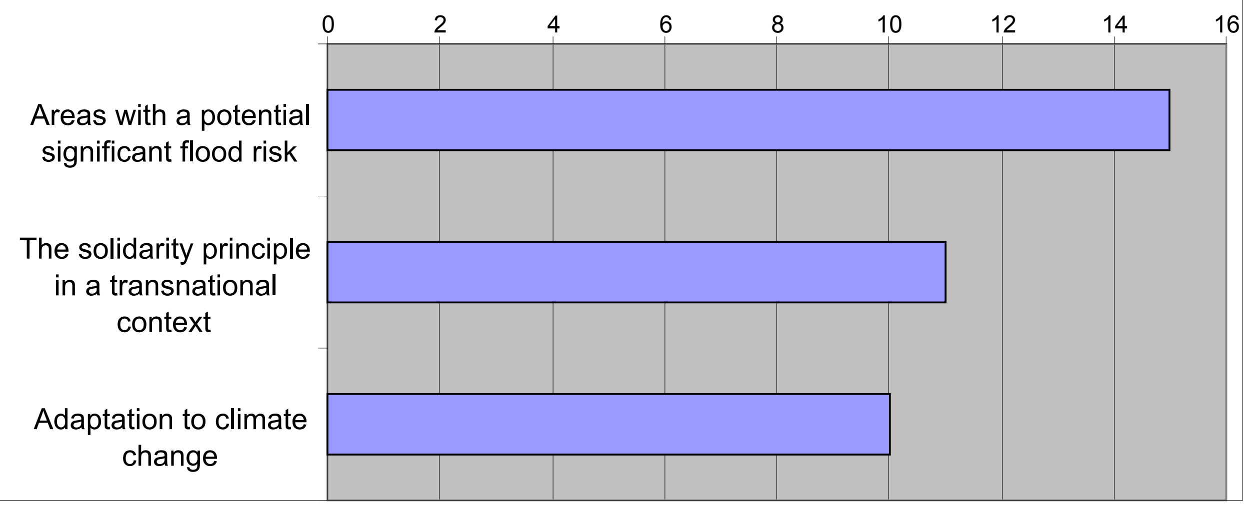
As already stated in the Maastricht workshop, the current European system of funding (no cost differentiation) doesn't fit with the characteristics of the implementation of measures from FRMP's (raising of costs during the implementation of the measures).

Cross Compliance is already partially implemented for the WFD, and it is not clear if it will be implemented for the FD. Water retention measures in many cases conflict with agricultural interests, so it is important to work on measures with multiple benefits and to implement this principle in CAP. In general 'green infrastructure' and win-win measures should be promoted by EU funding. The Stirling workshop expressed concern that the current Common Agricultural Policy could inhibit delivery of important changes in land use that will be necessary to deliver truly catchment focused flood risk management. CAP as a funding mechanism for delivering catchment flood risk management on the ground is properly considered as part of the current EU budget review.

Finally there are questions on the reasons why only 20% of available EU budget has been used by September 2010.

Questionnaire results reveal the preferences for prioritisation criteria for future EU funding.

Q38. Can you give your preferences for possible prioritisation criteria for future EU funding?



7 Conclusions and recommendations

In the Ghent workshop participants agreed on the importance of economic assessments (EA) in the process of flood risk management, both supporting political decisions (policy appraisal) as well as technical decisions (investment appraisal). Economic analysis is not the only instrument, but EU Member States recognise the key role of it in flood risk analysis and in selecting and prioritising measures to manage flood risks. EA can provide reliable information for politicians and stakeholders, and they can justify and explain prioritisation of measures and allocation of resources to execute them. Member States clearly plan to intensify their efforts in this field.

An important conclusion in Ghent was that economic assessments could deliver mechanisms for compensation of transboundary effects related to the solidarity principle, and cross-border cooperation should be supported by appropriate funding.

Synergies between art. 5 of the WFD and art. 6 of the Floods Directive should be maximised to optimise coordination, and information and experiences with this coordination should be exchanged. In doing economic assessments for the Floods Directive, WFD aspects should be taken into account. Synergies can be found in hydromorphological measures and natural flood risk measures.

Ghent workshop participants agreed that future scenario's for FRM (climate change, land use change, population growth, wealth growth,…) should be taken as basis for reaching objectives, instead of reaction on past events. To take into account future scenario's there is a need for data to monetise or quantify them, otherwise assessments on qualitative level are necessary. There are doubts if floods could have long term effects on competitiveness.

Ghent workshop participants concluded that uncertainty is inherent to decision making and looking into the future. This should be highlighted to policy makers. It is recommended to decrease the uncertainties in economic assessments in order to cope with critics of the public, because the principle of cost recovery will become necessary for future financing instruments.

Stakeholder participation was also discussed in the Ghent workshop. The use of maps reflecting hazard, vulnerability and risk is important for communication with the public, but they should not be too complicated and easy to understand for the public. These maps should focus on the areas of potential significant flood risk. Detailed information is not always available. People are mainly interested whether their property will flood or not, so a minimal level of detail is necessary. It is important to show comparable numbers (like numbers of houses and people affected), and they should be harmonised as much as possible. Stakeholders can discuss on relative weights of criteria in the decision frameworks, but it is questioned that it always leads to an acceptable outcome. In communicating criteria and results, the number of parameters should be minimised, e.g. to the 4 types of impact (economic, social, environmental, cultural).

The Ghent workshop participants recommended to make use of economic assessments on strategic level to reach the best mix of measures, meaning the right balance of prevention, protection, preparedness, mitigation and recovery measures, depending on the physical and social context. Flood risk management plans (FRMP) should be the framework for these strategic decisions. FRMPs will include many different types of actions including non-structural measures, and the limited experience with economic assessments of non-structural measures is a difficulty to overcome. In addition, many floods on local level are difficult to assess economically on strategic level of FRMP (e.g. pluvial floods may happen anywhere and at any time). It was also concluded that economic assessments on strategic level are able to support protection of non-developed flood prone areas under high spatial pressure, induced by preferences of living in the countryside and in the neighbourhood of water, and by industrial or harbour developments. Prevention of inappropriate development is also essential in order to safeguard downstream areas from flooding. If there is no possibility for legal constraints, at least guidelines for land use planning and resilient building should be developed.

An important issue is how to combine the different categories of impacts into one risk indicator, when monetary assessments have to be combined with quantitative and/or qualitative assessments. Although in the Ghent workshop many questions remained on how to evaluate impacts on the 4 different types of impact of floods, it was concluded that there are enough examples of good practice available for economic, social, ecologic and cultural heritage impacts. Impacts should be monetised as far as possible in order to evaluate the different impacts within the same measure, but it is not necessary to express all aspects monetary because it is not possible (lack of data, uncertainties) or not wanted. The aggregation of the different categories of impacts into risk is the most questioned problem. As a solution it is proposed to use a multi-criteria analysis (MCA) with a limited number of criteria to aggregate, easy to understand, e.g. 50% economic, and 50% intangibles (social, environmental, cultural). These are also the key elements of the Directive to focus on. Integration of the impacts of several return periods (at least 3) is needed to assess the risk, so it is very important to include maps for different frequencies and to combine the vulnerabilities or damages with the hazards to produce a risk map.

Annexes

Annex 1 Key Member States links to guidelines for economic assessments in FRM (answers to questionnaire Q6)

BEF: MIRA research report 2006

CH: www.econome.admin.ch

http://www.bafu.admin.ch/publikationen/publikation/00806/index.html?lang=en&download=NHzLpZig7t,lnp6I0NTU042l2Z6ln1ad1IZn4Z2qZpnO2Yuq2Z6gpJCGdoB8hGym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2IdvoaCVZ,s-.pdf
http://www.bafu.admin.ch/publikationen/publikation/00804/index.html?lang=en&download=NHzLpZig7t,lnp6I0NTU042l2Z6ln1ad1IZn4Z2qZpnO2Yuq2Z6gpJCGdoB8gmym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2IdvoaCVZ,s-.pdf

CZ: Guidelines of European Investment Bank for Flood Risk Measures Program

DE: LAWA-Leitlinien zur Durchführung dynamischer Kostenvergleichsrechnungen (Guidelines for the dynamical cost comparison method); http://www.lubw.baden-wuerttemberg.de/servlet/is/14024/?shop=true

EI: A standard methodology is specified by the OPW.

NL: See http://www.rijkswaterstaat.nl/kenniscentrum/economische_evaluatie/kaders_en_documenten/

SI: Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance (www.uradni-list.si/1/objava.jsp?urlid=200660&stevilka=2549) and Handbook on cost and benefit analysis of investment projects (http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide02_sl.pdf)

UKE: Defra Policy Statement on Appraisal: http://www.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf ; Environment Agency Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG): http://www.environment-agency.gov.uk/research/planning/116705.aspx

Annex 2 Member States references to projects where economic assessment was important for decision making (answers to questionnaire Q10)

AT: Flood protection measures on the river Glan for the cities of St.Veit/Glan and Klagenfurt: basin-wide flood management system (flood retention ponds) optimised using the CBA-tool

BEF: Controlled flood reservoir Dender (first example); Revised Sigma Plan (1st refinement and victim modules); Integrated Coastal Management Plan (different mechanisms: water velocity on dykes, victims due to collapse, "infinite" mass of flood water).

CH: To be financially supported by our Office in Switzerland, all technical projects for FRM must be evaluated using our standardised method cost-benefit.

CZ: European Investment Bank and Ministry of Agriculture of The Czech Republic have common project "Flood prevention program II". The methodology for evaluation of measures is meant above (CTU Prague).

DE:
http://www.smul.sachsen.de/umwelt/wasser/download/051206_HwskMaListe_GU_HswskRang_051206.pdf

In preparation of the Flood Protection Investment Programme of the Free State Saxony, app. 1600 individual measures were proposes, assessed and prioritized. The prioritized list of measures was accepted by the Government of the Free State, directed towards the Parliament (Sächsischer Landtag) published and put in the Internet for free access to all citizens. It is a strong planning, monitoring and evaluation tool. National and European audits start with this planning instrument. Another approach from Baden Wuerttemberg is attached to this file:

HWRMP
Priorisierung von I

EI: Assessments are used for all Flood Relief Schemes (approx. 50 completed over last 15 years, are underway or at design stage). PFRA – Currently completed to draft stage for primary stakeholder consultation, but not yet publicly available

ES: Patricova: http://www.cma.gva.es/web/indice.aspx?nodo=1234&idioma=C

Regional Action Plan on prevention sectoral flood risk in Community Valenciana.

An "Information system of flooded and torrential areas in the Principality of Asturias" was developed in 2004 (http://tematico.asturias.es/112asturias). An aggregated indicator of vulnerability was developed, which integrated four vulnerability categories: economic (direct and indirect), social, community disruption and cultural heritage. This system is now under revision and updating, also with integration of environmental impacts.

FI: In the cases of flood protection of the cities of Pori and Huittinen economic assessment is playing an important role in the profitability assessment of different flood protection measures and in the selection of cost-efficient combination of flood protection measures between various different options. The role of economic assessment is important in these cases because there are several possible measures and combinations of measures that could be used to ensure adequate flood protection. (There are no references or web pages in English)

FR: In the area of the city of Nîmes in the southern part of France, several more or less expensive options for flood protection, all including the State's contribution, were on the table. The choice between one of these options has been made up thanks to a cost benefit analysis.

NL: CBA Room for the River (http://www.ruimtevoorderivier.nl/files/Files/Rapporten%20ed/Kosten-Batenanalyse/kba-1.pdf) (http://www.ruimtevoorderivier.nl/files/Files/Rapporten%20ed/Kosten-Batenanalyse/kba-2.pdf): justification of project objectives and selection of measures

Compartimenteringsstudie http://english.verkeerenwaterstaat.nl/kennisplein/3/8/389395/verkenning_van_nadere_compartimentering_van_dijkringgebieden_130809.pdf . No justification of compartmentalisation dikes.

http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2008/01/01/kengetallen-kosten-batenanalyse-waterveiligheid-21-eeuw.html

Possible adjustment of legal flood protection standards on basis of CBA + Rampenbeheersingsstrategie (RIZA, 2005)

RO: In case of Prut Basin, a prioritization of investments was provided based on risk analysis and of cost-benefit analysis. This example can be find on www.apeprut.ro . This study just passed SEA procedure including public consultation and is available on the site at the moment.

SI: All flood protection measures, financed by Water fund are subject to economic assessment (EA). Main objective of the economic assessment is to find the most efficient, environmental acceptable and cost-effective technical solution to achieve the objective regarding also possible financing sources. Benefits of such measures are also part of the assessment and are expressed in a qualitative and quantitative way.

UKE: National level: Long Term Investment Strategy, 2009: http://www.environment-agency.gov.uk/research/library/publications/108673.aspx . Economic appraisal using national modelling set out potential future investment scenarios and resource requirements. Regional level: Thames Estuary 2100 strategy (see Chapter 7 of the Plan document):

http://www.environment-agency.gov.uk/research/library/consultations/106100.aspx

Economic appraisal was important not so much to justify action but to make meaningful choices between different strategies, taking into account the full range of potential impacts. Local Level: Pagham to East Head Coastal Defence Strategy (attached). A typical example of a report to determine optimum local management, guided by economic appraisal of costs and benefits. In this area there is a range of recommendations, from justifying continued maintenance and investment in some areas, through to managed retreat in others. Economic assessment was important here to guide decisions maximising value for money within a constrained national investment programme.

UKN: Northern Ireland was subject to a widespread, extreme rain event which cause significant flooding during August 2008. Site specific reports have been completed for various locations, for example http://www.riversagencyni.gov.uk/index/rivers-agency-publications/reports_on_previous_flooding_incidents/rivers_agency_publications-newpage_august_2008-_flooding_incidents/rivers_agency_publications_doagh_river/doagh_river_full_technical_and_non_technical_reports.htm . This report includes consideration of the economics of the proposed works.

Annex 3 Member States links to climate change and land use change scenarios (answers to questionnaire Q21)

Climate change scenario's

http://www.kuleuven.be/hydr/CCI-HYDR.htm

http://www.lawa.de/documents/LAWA_Strategiepapier_1006_d07.pdf

http://www.bmu.de/files/pdfs/allgemein/application/pdf/das_gesamt_bf.pdf

http://www.kliwa.de

http://www.likumi.lv/doc.php?id=42348

http://www.vidm.gov.lv/lat/likumdosana/normativie_akti/?doc=3158

http://kalme.daba.lv/en

PL: PESETA project (Projection of Economic Impacts of climate change in Sectors of the European Union based on bottom-up Analysis)

RO: CoRe project

http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence

http://www.environment-agency.gov.uk/research/library/publications/108673.aspx

http://www.environment-agency.gov.uk/homeandleisure/floods/104695.aspx

http://www.defra.gov.uk/environment/flooding/documents/policy/guidance/fcdpag/fcd3climate.pdf

Land use change scenario's

http://www.rimax-hochwasser.de/forschung.html

http://www.ella-interreg.org/index.php?id=404

http://www.landesentwicklung.sachsen.de/6102.htm

http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence

http://www.defra.gov.uk/environment/flooding/documents/policy/guidance/fcdpag/fcd3climate.pdf

Annex 4 Catalogue of flood consequences

Level 1	Level 2	Level 3	Level 4
Social	Impact on human health	Quasi direct physical health effects	Injuries from being knocked over by flood water, thrown against hard objects or struck by moving objects; injuries from over-exertion during the flood (e.g. sprains); hypothermia; cold, coughs, flu, headaches; sore throats or throat infections; skin irritations (e.g. rashes)
		Longer term physical health effects	Gastro-intestinal illnesses; cardiac problems; respiratory problems (e.g. asthma, chest infections, pleurisy); lacerations, abrasions and contusions; sprains and strains; skin irritations (e.g. rashes, dermatitis, etc.); high blood pressure; kidney or other infections; stiffness in joints; muscle cramps; insect or animal bites; erratic blood sugar level (diabetics); weight loss or gain; allergies (e.g. to mould spores)
		Pshycological health effects	Anxiety (e.g. during heavy rainfall); panic attacks; increased stress levels; depressions; lethargy / lack of energy; feelings of isolation; sleeping problems; nightmares; flashbacks to flood; increased use of alcohol or drugs; Anger/tantrums; Mood swings/bad moods; increased tensions in relationships (e.g. more arguing); difficulty concentrating on everyday tasks; thoughts of suicide
		Death	
	Impact on family life and social relations	Difficulties in meeting basic needs	
		Duffuclties in recovering the house	
		Difficulties in coping with relatives suffering from heath problems	
		Evacuation from the area	
		Loss of time and recreational opportunities	
		Disruption of financial situation	
	Disruption of community services	Education	
		Governance	
		Health and home care	
		Security	
	Loss of memorabilia and irreplacable items		
Economic	Buildings and content	Residential	Damage to the building frabric
			Damage to contents (domestic appliances; electrical appliances; furniture and furnishings; clothes; ...)
			Damage to vehicles
		Industry, retail sector; distribution sector; hotels and catering businesses; offices; sports and leasure facilities; public buildings of all kind	Damage to the building frabric
			Damage to building services
			Damage to movable equipment
			Damage to fixtures and fittings
			Damage to stocks
			Loss of earnings (not always an economic cost)
	Public utilities and related infrastructure	Damage to power plants	
		Damage to water and sewage treatment plants	
		Damage to electricity, gas, district heat, water and telecommunications transmission infrastructure	
		Losses caused by the disruption of electricity, gas, district heating, water and telecommunication services (not always an economic cost)	
	Transport infrastructure	Damage to the road, railway, port and airport infrastructure	
		Losses caused by the disruption of the road and railway network and port and airport infrastructure (not always an economic cost)	
	Agriculture	Arable	Damage to land
			Damage to crops
			Damage to equipment
		Livestock	Loss of livestock
			Damage to land
			Temporary loss of grazing
		Horticulture	Damage to land
			Loss of produce
		Forestry	
Environment	Impact on the quantity and quality of ecosystem goods and services		
Cultural heritage	Damage to build-up heritage		
	Damage to parks and gardens		
	Damage to archaeological sites		

Annex 5 Catalogue of methods for the assessment of the consequences of flooding

Draft fact sheet for introducing/describing specific methods for the assessment of the consequences of flooding to a specific receptor

Parameter	Description
Name	Short name, including enough information to distinguish between different indicators and methods
Receptor adressed	Reference to the specific receptor (either social, economic, environmetal or cultural heritage value) that can be assessed with this method
Summary	Brief overview of method, receptor data and indicator output
Input data: receptors	Description of the receptor data required for calculation: vector/raster, coverage, scale, accuracy
Input data: flood hazard	Description of the flood hazard data required for calculation
Output	Description of the scale of the output (monetary, quantitative, qualitative), the level of detail, accuracy, etc.
Method	Description of how to perform the calculation; possibly making reference to more detailed information on the method
Provenance	Where has this method been used before? Where was it developed? How has is been validated?
Comments	Advantages of the method and proof of likely successes, drawbacks and potential problems, practical experiences of prior use, alternative indicators or methods, specific recommendations for application elsewhere, etc.

Examples of fact sheets from France: 3 monetised and 4 non-monetised receptors

Parameter	Description
Name	Costs to residential
Receptor addressed	Economics - Residential
Summary	Assessment of housing into the flooded area, modelling of the water depth and use of damages curves related to water-depth
Input data: receptors	Number of housing at the first floor, or surface of housing at the first floor
Input data: flood hazard	Mean water-depth in the flooded area
Output	Monetary value of the damages (euros), by house/flat or by building, depending on if you used the number of housing or the surface
Method	CBA Crossing of water-depth related damages curves with the input data
Provenance	Classic use of water-depth damages curves. The Ministry for Sustainable Development is now developing its own curves, in the same way the FHRC did (modelling of the damages to each part of housing, and creation of "mean housing"). In the same time, we collected damages data in order to check that the curves are fitting the reality
Comments	Still under development - nevertheless, there are already damages curves used in France since 1991 (like those from Torterotot)

Parameter	Description
Name	Costs to firms
Receptor addressed	Economics - Industry and retails sectors
Summary	Assessment of firms into the flooded area, modelling of the water depth and use of damages curves related to water-depth (depending of the type of firm)
Input data: receptors	Number of surface of flooded firms
Input data: flood hazard	Mean water-depth in the flooded area
Output	Monetary value of the damages (euros)
Method	CBA Crossing of water-depth related damages curves with the input data
Provenance	Classic use of water-depth damages curves. The Ministry for Sustainable Development is now developing its own curves, in association with the association of French claims adjusters
Comments	Still under development - a test is going to be run during the summer 2012, and we should have something for May 2013

Parameter	Description
Name	Costs to agriculture
Receptor addressed	Economics - Agriculture
Summary	Assessment of both the surfaces of land and the number of farms, crossing with damage curves
Input data: receptors	Number of flooded farms and surface of land. For each type of farming, depending of the season, the equipment, the buildings and the stocks are given (no need to check into a database or in the reality)
Input data: flood hazard	Mean water-depth in the flooded area, mean velocity, salinity and season
Output	Monetary value of the damages (euros)
Method	CBA For the equipment, stocks and the buildings : crossing of the receptors data with the curves. For the land : the curve is depending of the type of plantation and of the season, and gives a percentage a loss of the added value at the harvest. The value of the harvest is given by using local data furnished by the Ministry of Agriculture (mean prices at the local scale)
Provenance	Classic use of water-depth damages curves. The Ministry for Sustainable Development is now developing its own curves, in association with the several experts in agricultural development
Comments	The lands curves are almost done. We have yet to work on equipment, buildings and stocks - it should be achieved for May 2013

Parameter	Description
Name	Human health - including 8 indicators
Receptor addressed	Social
Summary	The aim of these 8 indicators is to give an overview of the consequences of the assessed project in terms of human health : 1. Number of people into flooded area, and percentage relative to the total population 2. Percentage of people living into houses with only one stage 3. Number of people depending on flooded drinking water catchment 4. Size of the flooded camping and hosting centres 5. Size of the flooded buildings with fragile people (nursing home, for instance) 6. Size of the flooded health facilities 7. Percentage of flooded and non-flooded buildings supposed to be help at the crisis (firemen station, for instance) 8. Size of the non-flooded buildings able to host refugees
Input data: receptors	Surface of housing places and their heights, size of the population in the area, localization of drinking water catchments, localization of health facilities, localization of campings and hosting centres, localization of official buildings, crisis management plans
Input data: flood hazard	Only the localization of the flooded area, and if the water-depth is higher than 1 meter or not
Output	Quantitative : for each of the 8 indicators, we get the evaluation before and after the implementation of the assessed measure (we just cross the localization of the receptors with the flooded zone). And the indicators is calculated twice, to assess the number of receptors into the "more than one meter of water-depth area", which is the more dangerous
Method	MCA A guide will be released for local stakeholders, including detailed explanations (which database to use, how to perform the calculation, …)
Provenance	2 years of a working team including representatives from the Ministry (in Paris or in local administration) and local stakeholders, on the basis of the work done for the Flood Directive Preliminary Evaluation
Comments	The whole method is going to be tested in the next summer (2012), and should be released in May 2013

Parameter	Description
Name	Environment - including 4 indicators
Receptor addressed	Environment
Summary	The aim of these 4 indicators is to give an overview of the consequences of the assessed project in terms of protection of the environment : 1. Mean daily volume treated by the flooded water treatment plants 2. Capacity of stock and treatment of waste of the flooded plants 3. Surface of flooded protected natural area 4. Number of flooded IPPC or Seveso installations
Input data: receptors	Localization of water treatment plants, localization of plants for treatment and stock of waste, surface and localization of protected natural areas, localization of IPPC or Seveso firms
Input data: flood hazard	Only the localization of the flooded area
Output	Quantitative : for each of the 4 indicators, we get the evaluation before and after the implementation of the assessed measure (we just cross the localization of the receptors with the flooded zone).
Method	MCA A guide will be released for local stakeholders, including detailed explanations (which database to use, how to perform the calculation, …)
Provenance	2 years of a working team including representatives from the Ministry (in Paris or in local administration) and local stakeholders, on the basis of the work done for the Flood Directive Preliminary Evaluation
Comments	The whole method is going to be tested in the next summer (2012), and should be released in May 2013

Parameter	Description
Name	Cultural heritage - including 2 indicators
Receptor addressed	Cultural heritage
Summary	The aim of these 2 indicators is to give an overview of the consequences of the assessed project in terms of protection of our cultural heritage : 1. Mean yearly number of visitors into the flooded museums 2. Number of flooded patrimonial buildings and protected sites
Input data: receptors	Localization of museums, patrimonial buildings and protected sites
Input data: flood hazard	Only the localization of the flooded area
Output	Quantitative : for each of the 2 indicators, we get the evaluation before and after the implementation of the assessed measure (we just cross the localization of the receptors with the flooded zone).
Method	MCA A guide will be released for local stakeholders, including detailed explanations (which database to use, how to perform the calculation, …)
Provenance	2 years of a working team including representatives from the Ministry (in Paris or in local administration) and local stakeholders, on the basis of the work done for the Flood Directive Preliminary Evaluation
Comments	The whole method is going to be tested in the next summer (2012), and should be released in May 2013

Parameter	Description
Name	Economic - including 6 indicators
Receptor addressed	Economic
Summary	The aim of these 6 indicators is to give an overview of the consequences of the assessed project in terms of protection of economical assets : 1. Surface of flooded firms and housing 2. Daily traffic onto the flooded transportation facilities 3. Number of flooded sites related to energy and telecommunication (like electrical transformers, for instance) 4. Percentage of firms related to publics works which would be flooded 5. Number of working people into the flooded area 6. Surface of flooded agricultural areas
Input data: receptors	Surface of firms and housings buildings, localization of the transportation facilities and associated traffic, localization of the energy and telecommunication network, localization of the public works firms, number of workers and localization of the firms, localization of the agricultural areas
Input data: flood hazard	Only the localization of the flooded area
Output	Quantitative : for each of the 6 indicators, we get the evaluation before and after the implementation of the assessed measure (we just cross the localization of the receptors with the flooded zone).
Method	MCA A guide will be released for local stakeholders, including detailed explanations (which database to use, how to perform the calculation, …)
Provenance	2 years of a working team including representatives from the Ministry (in Paris or in local administration) and local stakeholders, on the basis of the work done for the Flood Directive Preliminary Evaluation
Comments	The whole method is going to be tested in the next summer (2012), and should be released in May 2013

Annex 6 Examples of methodologies for vulnerability and risk assessment (answers to questionnaire Q23)

Examples with assessment of consequences on the economy (and other aspects):

www.wassernet.at

www.milieurapport.be

www.econome.admin.ch

www.lawa.de/documents/LAWA_HWRM-Plaene26032010_Text_Germany_ENG_5d4.pdf

www.cepri.net/upload/pagesstatiques/fichiers//manuelpratiquesexistantesversiondfinitive.pdf

polsis.mk.gov.lv/LoadAtt/file46448.doc

www.helpdeskwater.nl/waterkeren/veiligheid_nederland/

www.helpdeskwater.nl/waterkeren/veiligheid_nederland/project_vnk2/waterveiligheid_in/

www.danubefloodrisc.eu

www.rowater.ro

www.hidro.ro

www.mmediu.ro

www.mai.gov.ro

www.igsu.ro

www.uradni-list.si/1/objava.jsp?urlid=200760&stevilka=3216

www.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf

www.environment-agency.gov.uk/research/planning/116705.aspx

Examples with assessment of consequences on human health:

www.ms.gov.ro

www.igsu.ro

www.defra.gov.uk/environment/flooding/documents/policy/guidance/fcdpag/risktopeople.pdf

Examples with assessment of consequences on the environment:

www.wassernet.at

www.mmediu.ro

Examples with assessment of consequences on cultural heritage:

www.cultura.ro

Annex 7 Key Member States links to appraisal methods of measures (answers to questionnaire Q 28).

wasser.lebensministerium.at/article/articleview/49199/1/14407/

www.wassernet.at

www.econome.admin.ch

www.smul.sachsen.de/umwelt/wasser/download/051206_HwskMaListe_GU_HswskRang_051206.pdf

www.ikse-mkol.org/index.php?id=564&L=2

www.iksr.org/index.php?id=105

www.chcantabrico.es

www.helpdeskwater.nl (hoogwaterbeschermingsprogramma)

www.mmediu.ro

www.apeprut.ro

www.rowater.ro

www.hidro.ro

www.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf

www.environment-agency.gov.uk/research/planning/116705.aspx

Annex 8 Catalogue of methods for financing flood risk reduction measures

Draft fact sheet for describing specific methods for financing flood risk reduction measures

Parameter	Possibilities
Aim	Regulatory versus financing
Base of taxation	Increas in the impermeability of the surface of a lot; reduction of the flood risk of a property
Tax payer	Owner of a building / owner of residential building / owner of a building for commercial activities; New constructions / existing constructions
Tariff	Linear / progressive / regressive; announced / yearly adaptable; Increasing / decreasing / fixed over time
Time perspective	Temporal (duration announced in advance) / permanent; Simultaneous / phased introduction for different sectors (e.g. test cases, different timing for the residential sector)
Geographical perspective	The entire region / areas-at-risk only / differentiation between upstream and downstream areas
Reductions and exemptions	Reductions on the basis of the realisation of compensatory measures per lot; Reductions for lots that do not generate (additional) run-off; Exemption when constructions occupy less than a certain surface

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